Final Report

Westinghouse
Health Systems

Systems Analysis Study Towards a "New Generation" of Military Hospitals

Volume 2
Systems Analysis

(1)

SYSTEMS ANALYSIS STUDY TOWARDS A "NEW GENERATION" OF MILITARY HOSPITALS

VOLUME II: SYSTEMS ANALYSIS

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PREFACE

This is Volume II, Systems Analysis, of a five-volume final report submitted by the Westinghouse Electric Corporation to the Department of Defense for work performed on Contract Number DAHC15 69 C 0354, Systems Analysis Study Towards a "New Generation" of Military Hospitals.

The primary task of this study was to develop alternative hospital system designs, using current state-of-the-art concepts, technology, and management procedures with the objective of designing the most efficient hospital for construction commencing in mid-1972. The secondary task was the definition of system improvements arising from R & D opportunities available in time for prototype construction in the 1975-1980 period.

The remaining four volumes contained in this report are:

VOLUME	TITLE
I	Executive Summary
III	Medical Health Care Review
IV	State of the Art
V	Data Inventory

ACKNOWLEDGEMENT

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ABSTRACT

This is Volume 2 and presents the results of a systems analysis of the Base Level Health Care Systems (BLHCS), in the continental United States, with the objective of improving the operating efficiency of the individual BLHC System, while maintaining or improving the quality of patient care.

The areas of analysis are:

- Health Care Planning - The prediction of health and patient care requirements for the BLHC System.
- Systems Design Concepts - The process of designing a BLHCS facility concept which can respond to demands for change and growth initially and over time.
- Operations Analyses - The management of resources within the facility to provide health care and patient support, including:

  Communications and Data Management
  Materiel Handling
  Dietary
  Clinical Laboratory
  Dentistry
  Outpatient Department
  Ward Management
  Education and Training
  Pharmacy
  Radiology

- Systems Application - An application of the planning, design, and operations analyses to the design of a BLHC System at a hypothetical "Base X".

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1. SUMMARY AND RECOMMENDATIONS

The Westinghouse Systems Analysis Study Towards a "New Generation" of Military Hospitals (NGMH) has been performed to identify and describe potential improvements in facilities, resources, and programs of the Base Level Health Care (BLHC) Systems operated by the Department of Defense for 10 million eligible military on active duty or retired, their dependents, and dependents of deceased military personnel.

This study is Phase I of an ongoing development effort. The objectives of the Westinghouse Phase I effort were:

- to mobilize health care resources for maximum effectiveness and efficiency
- to minimize system life cycle costs, including operating and capital expenditures
- to enable the System to respond to changes in technology, health care trends, and mission or policy.

Phase II will implement Phase I concepts and develop other promising system improvements. Continuing effort through Phase II and beyond will lead to a New Generation of Military Hospitals.

SCOPE OF THE STUDY

The scope of Phase I of the NGMH study was the performance of systems analyses toward improving the construction, planning, maintenance, and training efficiency of the individual BLHC System while maintaining or improving the quality of patient care. A BLHC System is defined as the facilities and resources necessary to provide a full range of health care services to the components of the military community, armed forces personnel, their dependents, and other authorized categories residing on, adjacent to, or referred to the system. It will also provide designated health care services and military

command and control responsibilities to health care facilities beyond its established boundary. (These are considered external demands upon the BLHC System.)

The basic mission of the BLHC System is to:

- Maintain the physical, mental, and operational fitness of the assigned population
- Prevent and control the incidence of disease and injuries within the BLHC System

The services provided by a Base Level Health Care System include:

- General short-term hospital beds with related diagnostic and therapeutic capability
- Inpatient and outpatient clinics
- General and preventive dentistry
- Dispensary care
- Aerospace and aviation medicine
- Preventive medicine
- Mental and social health care
- Veterinary medicine

The external demands that are placed upon the BLHC System can be defined as:

- The treatment of battle casualties
- The designation as a medical and dental specialty treatment center
- Area medical materiel management responsibility
- Area medical command and control responsibility
- Intransit aeromedical evacuation facilities.

Phase I was divided into three basic activities:

- Operations analysis
- Improvement analysis
- Results and recommendations

The operations analysis described the performance of individual BLHCS, elements, functions, and sub-systems. It investigated and documented major functional costs, and it characterized the basic flows between functions.

The DoD selected three specific BLHC Systems for Westinghouse to study in depth and six BLHC Systems for general examination. The Systems were a representative sample of base missions and health care services.

The hospitals selected for in-depth study were:

280-Beds	Beaufort Naval Hospital, Beaufort, South Carolina
350-Beds	Malcolm Grow USAF Hospital, Andrews AFB, Maryland
900-Beds	Walson Army Hospital, Fort Dix, New Jersey

The hospitals selected for general examination and evaluation were:

175-Beds	USAF Hospital, March Air Force Base, California
250-Beds	U.S. Army Hospital, Fort Belvoir, Virginia
400-Beds	U.S. Naval Hospital, Jacksonville, Florida
500-Beds	U.S. Army Hospital, Fort Bragg, North Carolina
750-Beds	U.S. Air Force Hospital, Lackland AFB, Texas
650-Beds	U.S. Naval Hospital, Oakland, California

The improvements analysis assessed major improvement alternatives in terms of technology and its state of development, its impact on hospital management and organization, and its impact on BLHC organization and functions. Other considerations were: additional research and development required, the levels of uncertainty associated with possible alternatives, and policy issues raised by them. The improvement alternatives were submitted to a systems analysis and appropriately tested and evaluated. Cost/benefit studies on major improvement alternatives helped develop specifications and requirements for all recommended improvements.

Recommendations are made, in this Executive Summary and in appropriate volumes, first for construction of a prototype starting in mid-1972 and second, for long-term research and development in the 1975-1980 time frame.

THE WESTINGHOUSE APPROACH

Using a multidisciplinary approach, Westinghouse formed a Consortium of companies and individual professionals from the research, engineering, architecture, industry, management sciences, medicine, nursing, hospital administration, and health law fields. In a sense, only a multidisciplinary systems approach could be successful, since from the outset it was apparent that military hospitals are elaborate and complex systems which blend the "hard" sciences of engineering and construction with the "soft" sciences of medicine and health care.

The objective of the systems approach was to provide a total conceptual framework to accommodate both quantitative analysis and subjective evaluation. Many areas of the systems analysis required the highest level of judgment and experience from the professional specialists in the Consortium. The study's success can be directly traced to workable evaluations of the many qualitative factors that are integral to any health care system. Wherever possible, Westinghouse has identified in this report the areas where qualitative factors are important and how these factors relate to the analysis.

Six major tasks were defined in the Westinghouse proposal.

1. Pre-project Planning -- Westinghouse-funded effort to acquaint the Consortium with the military BLHC System and initiation of the state-of-the-art survey (SOA).
2. Preliminary Data Inventory -- the analysis of the data pack supplied by DoD.
3. Data Inventory -- detailed data collection and observation in nine military BLHC Systems.
4. Systems Analysis -- identification of alternative improvement possibilities and the detailed justification and comparison of these alternatives both individually and in combination.

5. Systems Design -- development of design plans for the circa 1972 military BLHC Systems and identification of R&D programs which will make contributions to the military BLHC System circa 1975-1980.
6. Presentations and Reports -- preparation of the findings of this 12-month study.

Figure 1-1 graphically describes the process and the interrelationships of all the study tasks within the systems analysis framework. As the model indicates, data gathering activities represented the major allocation of total study resources.

The initial project tasks, the assembly of a broad range of data on the present BLHC System, were required for a characterization of the military BLHC environment as it actually exists rather than as it is understood to exist. And throughout the study, this data intensive approach has left the audit trails vital to future productive efforts.

The BLHC System can be characterized as a comprehensive health care system. While it may have some elements of a specialty or regional referral system, it always provides a broad array of primary and short-term acute health care. In this sense it differs from most civilian community systems with their pattern of local private physicians' offices, group practices, and multi-specialty clinics which are coupled with small community and large regional hospital centers.

Compared to a civilian system, the military system is much more susceptible to change and growth; mission changes which alter the population mix or cause extreme demands for growth are common and have been generally unpredictable.

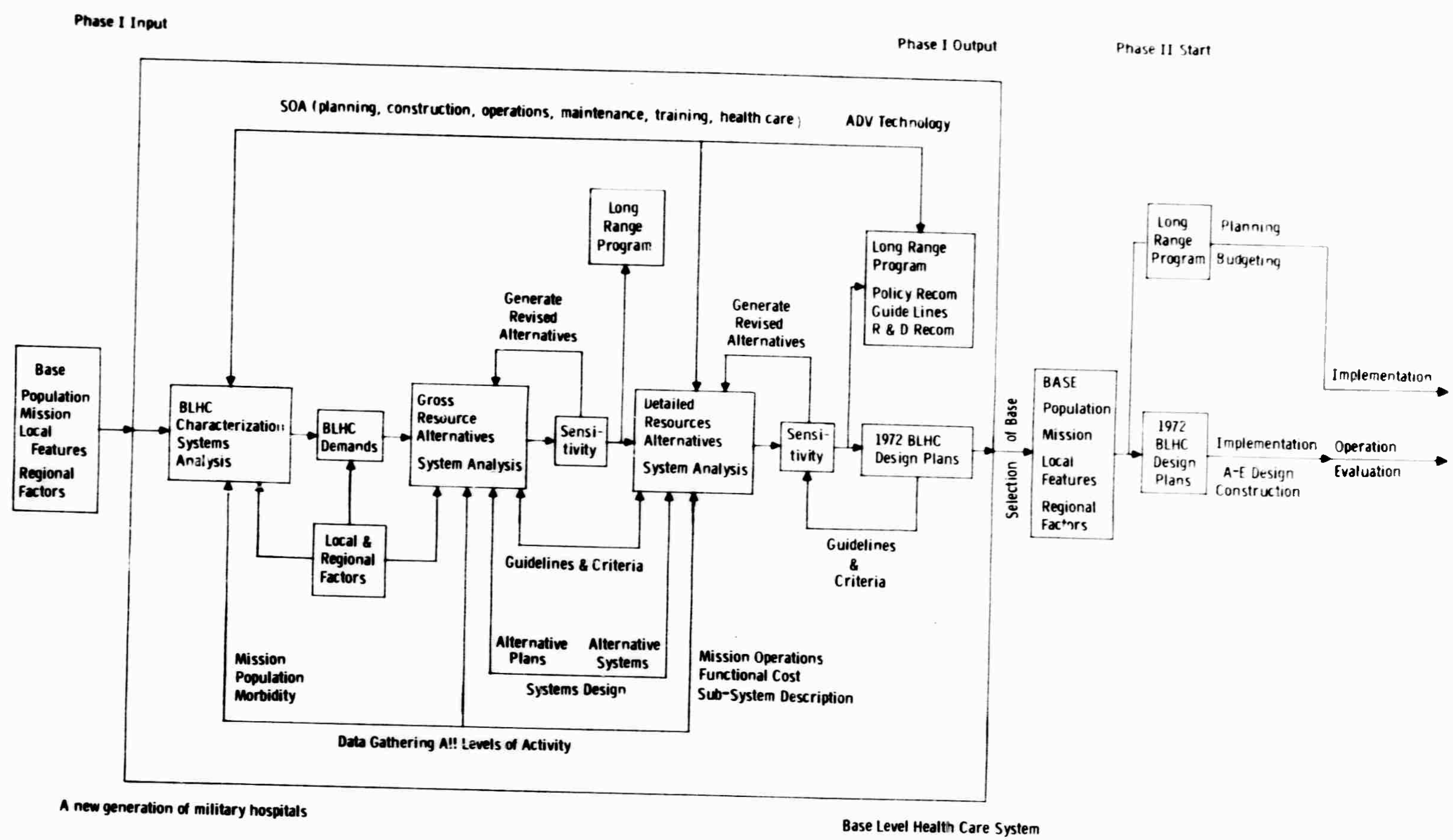


FIGURE 1-1 HEALTH CARE SYSTEMS MODEL
SHOWING PROCESSES AND INTERRELATIONSHIPS OF ALL STUDY TASKS WITHIN THE SYSTEMS ANALYSIS FRAMEWORK

STUDY CONSTRAINTS

Several constraints were imposed by the Department of Defense on the conduct of this Phase I study, A Systems Analysis Study Towards a "New Generation" of Military Hospitals. These constraints were:

- Alternative systems designs should be developed to serve military base communities with the DoD specified hospital capacities of:

Beneficiary Populations	Beds	Outpatient Visits per Year
40,000 - 50,000	250	300,000
60,000 - 80,000	500	450,000
80,000 - 100,000	750	650,000

- Studies should be limited to services provided at only the base level, i.e. primary hospital plus associated health facilities and dispensaries.
- Regionalization concepts above the base level should not be investigated.
- Disaster planning for natural disasters or mass evacuations should not be included.
- The alternative systems design will not assume relationships for shared services between the Base Level Health Care System and contiguous civilian or other non-DoD related health care facilities.
- The proposed systems concepts must comply with the appropriate governmental and non-governmental agencies regulations and policies pertaining to legal, professional and institutional considerations . . . such laws and regulations should be identified as constraints but should not be limiting in the development of proposals for new and improved operating procedures.

PROBLEM IDENTIFICATION

The fundamental fact which emerged from the study was the uniqueness of each individual BLHC System. Every System has different demands and performance requirements. Based upon that understanding, need for improvement became apparent in three basic areas of the system -- in planning, facilities design, and operations.

1. In planning, a need for a better method of predicting the changing demands a BLHC System must satisfy over its life cycle. Traditional planning methods had too often led to understated resource requirements and unmet health care needs. Needed was a tool to forecast health care requirements at various times in the future, a tool which would also convert those forecasts into specifications of the health care resources required.
2. In facilities design, a need for a system design concept which can respond to health care needs not only initially, but after significant changes and substantial growth. Present designs can rarely absorb rearrangements or modifications in response to new technology nor can they absorb the sometimes abrupt, and often large, expansions required by mission changes. The results have been facilities used in ways that were not intended, and costly modifications and expansions after systems had reached a point of saturation.
3. In operations, a need for resource management and for evaluating the array of sub-system or functional improvement opportunities (such as communications or dietary systems) which are already operational, or which are likely to be in the near future. An extension

of this need for evaluating sub-system alternatives was a method or framework for bringing the many alternatives together in the best combination for the optimal working of the system over its life cycle.

The primary focus was on providing a comprehensive approach for the overall system and sub-systems, with the knowledge that detailed problems can only be resolved within a sound overall framework.

SYSTEM ANALYSIS STUDY LIMITATIONS

A conventional systems analysis implies a high degree of precision in defining goals and measuring alternatives. However, even before the study began, certain constraints were identified that inhibit the performance of a classical systems analysis in the health care field:

1. Some areas, for example, medical practice, defy precise quantitative measurements. The evaluation and measurement of "quality" of patient care, of necessity, is highly subjective. Although some data in the area of medical practice was "hard" or quantifiable, most was qualitative judgments based on the highest level of professional expertise available. compensate for this limitation wherever it was possible to do so, sensitivity analyses were performed to determine the impact of these qualitative judgments, and thereby minimize the degree of uncertainty in the formal recommendations.
2. Another limitation was the relatively small sample from which the present BLHCS statistics were collected. Statistics such as costs and health care dynamics were used in many activities within the study, recognizing that they may not be totally representative of the entire BLHC System for all services. These numbers were used as composites or averages, and a basic assumption of the

study was that they would have to be further refined wherever they were applied to specific systems in future applications.

3. Because the health care field is such a complex system, all of its elements could not be characterized within the time and budget constraints of this study.
4. Much of the data generated has been a synthesis of both military and civilian data; this may cause some discrepancies, depending on the degree to which the civilian data does not represent the same health care dynamics as the military system.
5. Still another limitation arises from the non-uniform reporting of statistics from within the sample primary and secondary BLHC Systems studies.

BLHCS Characterization

The BLHC System is a comprehensive health care system providing a broad array of primary and intermediate levels of care to the beneficiary population. In this sense it is markedly different from most civilian systems, which are typically separate systems of ascending hierarchies of health care capabilities, functionally interrelated in a fairly flexible and cooperative environment, but administratively and physically separate. Each level of the civilian hierarchies, which range from private physician's offices to regional and national clinics, possesses a relatively narrow band of health care capabilities which approximates the BLHC System only in large, generally center city hospitals. Each depends on the level below to act as a triage mechanism to decrease the demand on other levels. Not only does the BLHC System embody elements of each of these hierarchies, but it may also embody unique mission assignments related to its military role.

Figures 1-2, 3, and 4 characterize both major systems. While civilian systems change gradually over time in response to socio-economic and demographic changes, the BLHC military system may change relatively rapidly in

GEOGRAPHIC POPULATION

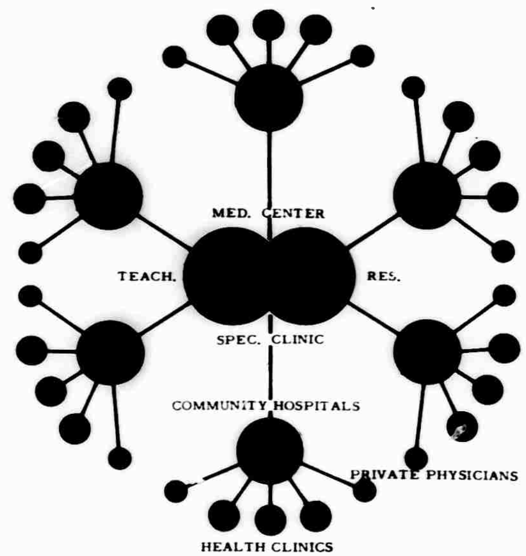


Fig. 1-2 The Community Health Care System

BENEFICIARY POPULATION

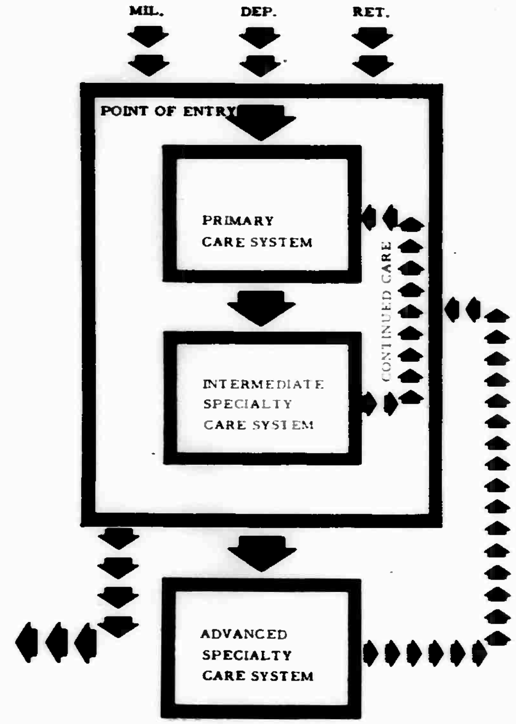


Fig. 1-3 The Military Health Care System

BLHC VARIABLES

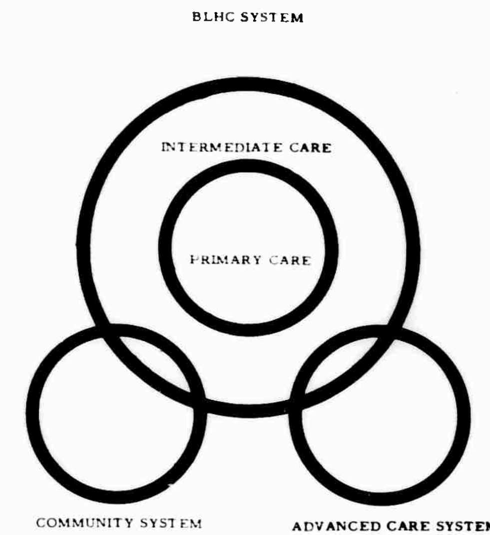


Fig. 1-4 The Scale Effects

response to mission changes. Mission changes can involve severe changes in population mix as well as total numbers in the population.

Ability to fulfill BLHC System requirements has been a prime factor in evaluating alternatives available from the state-of-the-art survey. Moreover, the design methodology and analytical tools which Westinghouse is recommending to the Department of Defense have been generated with sufficiently generalized parameters so that the performance of the BLHCS is not inhibited or constrained.

The Westinghouse systems analysis was based on the assumption that the Department of Defense will continue to offer the broadest array of health care possible within its BLHC Systems; the resulting recommendations are designed to enhance this ability and not simply to delete some of the most troublesome areas from the system.

RESULTS AND CONCLUSIONS

The study yields are presented in the following five areas:

1. A massive data resource on health systems in general and on the BLHC System in particular;
2. A demand model -- a method for translating BLHCS beneficiary population data into a statement of the health care required for those populations;
3. A design concept -- a facility organization that will provide a framework for operations and for change and growth over the life cycle;
4. Cost/benefit analyses on major health systems functional areas such as communications, dietary, and materiel handling.
5. Recommendations on medical care.

None of these yields is separate; to some extent they describe the process of the entire study, the path the Westinghouse group took in learning, conceptualizing, analyzing, and testing. Nor are they

necessarily in sequence; they are sometimes parallel, often interactive. They are presented separately to dramatize the fact that the sequence described -- planning, design, and operations -- can be performed over a period of time by different groups. The improvements and tools can be implemented and evaluated in toto or individually. And the careful audit trails provide continuing growth and development of all study yields.

The objectives described in the RFQ and Westinghouse commitments made in its proposal have been met, and more. In several instances during the study, Westinghouse has even contributed the use of proprietary software programs and other Corporate resources to further study goals.

The yields from the study meet the three categories of needs previously described with pragmatic and effective solutions.

- The responsive Westinghouse concepts for the NGMH can accommodate new ideas, changes in policy, changes in health care trends, as well as identified performance requirements.
- Planning and design tools developed are generalized solutions adaptable to any BLHC System. These concepts can respond to the uniqueness of every BLHC System.
- Planning and design tools can reduce the time between planning and occupancy.
- These concepts are not confined to the BLHC System; they will also be widely applicable by HEW, civilian hospitals, and the Veterans Administration.
- Many of these study results are not limited to new facilities, but have immediate appli-

cation to retrofit situations both inside and outside the BLHC System.

- Individual operations analyses have produced viable recommendations for the major subsystem areas.
- Medical care recommendations have balanced and guided engineering outputs throughout the study.

RECOMMENDATIONS

The recommendations resulting from the successful completion of the Department of Defense Phase I study — Systems Analysis Study Towards a "New Generation" of Military Hospitals, are summarized as follows:

	Source
• Proceed with Phase II implementing and evaluating the results of Phase I. The DoD should regard Phase II as a comprehensive and continuing R&D program, managed through planning, design and operations as a single and consistent process, without discontinuities in time and responsibilities. The same interdisciplinary approach which has proved successful in Phase I should be employed.	Volume I pg. 9
• DoD should establish a full-time interdisciplinary group to participate with industry in Phase II. This DoD group would be the new cadre of health care system planners who will become the	

core group for a larger staff necessary for the design, construction and operation of the "New Generation" of military hospitals.

The following recommendations have immediate applicability in all DoD existing facilities and should also be incorporated in the "New Generation" of military hospitals. These recommendations do not require Research and Development (R&D) efforts for implementation.

	Source
• Military careers should be made more attractive and competitive with civilian opportunities by expanding continuing education programs using self-instructional and multimedia aids, and provide opportunities for attending professional meetings and short courses, and developing a peer audit review system with assistance from the Joint Conference Committee of the American Medical Association.	Volume II pp. 3.3-150 to 172 Volume III pp. 33 to 54 Volume IV pp. 3-201 to 218
• Utilize a manual materiel handling system with exchange cart; the automated Power and Free materiel handling system should be considered for 200-300 and 700 to 800 bed BLHC Systems. • Large-cross-section pneumatic tubes should be installed to accommodate high-volume, high-frequency trash and soiled linen removal. • Investigate the use of automatic dumbwaiters for limited use in high-volume, high-frequency, non-level workload areas such as conventional dietary systems.	Volume II pp. 3.3-34 to 52 Volume IV pp. 3.232 to 252

	Source
• A combination of convenience foods and abbreviated kitchen for each nursing unit should be adopted; revise staffing and design criteria to allow for BLHC System-wide application.	Volume II pp. 3.3-53 to 68 Volume IV pp. 3-180 to 200
• Standardize clinical laboratory test procedures and equipment for more precise internal management and generation of more usable data for prediction of workload. • Automated clinical laboratory equipment costing over $35,000 should be leased and not purchased.	Volume II pp. 3.3-69 to 86 Volume IV pp. 3-37 to 57
• Utilize a staffing criteria to allow a ratio of one dentist to four assistants to three operatories. • Expand the practice of four-handed sit-down dentistry. • Increase the use of dental hygienists in preventive dental programs such as dental prophylaxis, fluoride treatments, water-supply fluoridation, and patient education on prevention of dental disorders.	Volume II pp. 3.3-87 to 100 Volume IV pp. 3-160 to 179
• Institute "outpatient surgery" as an integral part of the composite facility -- utilizing existing operating room suites, personnel and ancillary services.	Volume II pp. 3.3-101 to 110 Volume IV pp. 3-1 to 36

	Source
• Level the nursing workload by rescheduling from the peak morning hours of 0700 to 1000 procedures such as: Inpatient movement to ancillary areas Admissions/discharges Bed baths	Volume II pp. 3.3-111 to 149
• Employ the unit dose drug distribution with IV additive and Auxiliary Clinical Pharmacist for both inpatient and outpatient operations for all BLHC Systems of 200 beds or more. • Introduce a drug information center for 750- to 1000- bed BLHC Systems.	Volume II 3.3-173 to 190 Volume IV pp. 3-264 to 281
• Utilize the double corridor concept for improved staff and patient traffic patterns in Radiology Departments. • Generators equipped to serve several X-ray machines should be used rather than the existing use of one generator to one X-ray machine.	Volume II pp. 3.3-191 to 206 Volume IV pp. 3-307 to 324

The following recommendations for Short-Term R&D, that is research and development programs that can be completed in less than eighteen months, have been identified by Westinghouse.

- The data base for the Demand Model should be immediately extended and refined to show ancillary usage by level of dependency and by specialty clinic visit. The Demand Model's capabilities depend upon the quality and range of available data; this requires that the data and the Model itself be adjusted and updated on an ongoing basis. The Phase I study developed data to enable immediate application of the Demand Model.

- Investigate the implications of the Westinghouse Phase I study yields for BLHC Systems smaller than 250 beds and for specialty or regional referral centers.

Source: Volume II pp. 3.1-1 to 60

- Revise existing guidelines and criteria for planning, design, construction and staffing to facilitate incorporation of the various technological options and improvement alternatives into design specifications for the "New Generation" of military hospitals.

Source: Volume II pp. 3.4-1 to 84

	Source
• Investigate initial installation of a central dedicated processor with time-sharing capability having the essential features of: - central processor dedicated to the NGMH system - time-sharing by functions - commonly shared data base with a natural language interface - cathode ray tube for basic input/output media with limited hard copy capability. • Develop specifications for the use of microfilm for the production, storage, and retrieval of such data as medical records, admission, medical summaries and boards and its applicability to BLHC Systems.	Volume II 3.3-12 to 33 Volume IV pp. 3-58 to 126
• Determine the economic break-even point for dietary disposables and evaluate the consequent impact of disposables on the materiel handling system. • Develop specifications for computerized menu planning for more economical purchasing and inventory control procedures.	Volume II pp. 3.3-53 to 68 Volume IV pp. 3-180 to 200
• Develop a computerized, centralized and standardized data-collection system for major elements in the Base Level Health Care System.	Volume III pp. 94 to 101

	Source
• Develop specifications for computerized central appointment systems for clinics and outpatient services which can handle rescheduling, cancellations, and other varying demands upon the system while allowing flexibility for individual clinics.	Volume III pp. 94 to 101
• Provide audio-visual referral communications centers between BLHCS, dispensaries and University Medical Centers for consultation, to reduce the estimated fifty percent of hospital referrals, and to promptly alert hospital staff to the details of more acute problems and permit more rapid communication of health care data.	Volume III pp. 55 to 69
• Implement computerized techniques including automated testing procedures, terminals for laboratory result readout in nursing stations, outpatient departments, remote facilities, etc., communications systems with hospital decision-making centers, disease detection systems, and quality control for the Clinical Laboratories.	Volume II pp. 3.3-69 to 86 Volume III pp. 55 to 69
• Develop specifications for communications equipment for the Clinical Laboratory which can effect adequate and low-cost image storage and retrieval.	Volume II pp. 3.3-69 to 86

Source

- Establish an innovative position of "Barracks Health Master" with training in preventive medicine including communicable disease, safety, and trauma prevention. These corpsmen on the staff of the drill instructor, would be stationed in the barracks of recruit training centers to function with appropriate responsibility and authority. Such a position would reduce visits to dispensaries and outpatient clinics by recruits.
- Adopt the Physician's Assistant concept for all outpatient clinics in new BLHC Systems; utilize the Corpsman Physicians Assistant for clinics with predominate male patients and the Nurse Practitioner for clinics with predominate female patients.

Volume III pp. 33 to 54

- Reevaluate and revise outpatient clinic staffing and space planning criteria to allow for:
  - Operation of most clinics twelve hours per day, five days per week.
  - Provide two examining rooms per physician for most clinics.
  - Provide office space for physicians outside the clinic.
  - Meeting needs for patient-family education and counseling, including use of multimedia aids.

Volume II pp. 3.3-101 to 110

Volume III pp. 55 to 69

- Establish and computerize the Westinghouse "Graduate staffing" procedure to enable Nursing Service to vary unit staff on a daily basis as workload varies.

Volume II pp. 3.3-111 to 149

Volume IV pp. 3-337 to 360

•	Adopt the Modified Nursing Specialist - Unit Manager organization.	Source Volume II pp. 3.3-111 to 149 Volume IV pp. 3-337 to 360
•	Develop specifications for an education and training concept employing Integrated Media -- a combination of electronic dial access and instructional program management information and control; evaluate the feasibility of installing this system in existing BLHC Systems.	Volume II pp. 3.3-150 to 172 Volume IV pp. 3.201 to 218
•	Evaluate the applicability of the Radiology "Cluster Room" concept to military hospitals.	Volume II pp. 3.3-191 to 206 Volume IV pp. 3.307 to 324

The following recommendations for Long-Term R&D, that is research and development programs that require more than eighteen months of effort before completion of the program, have been identified by Westinghouse.

•	Develop nursing procedure time values by type of patient, level of patient dependency and type of nursing skill required.	Volume II pp. 3.3-111 to 149
•	Develop a uniform and comprehensive reporting procedure for all DoD health care services. Among the major findings of the Westinghouse Phase I study were the variety, inconsistency, and inadequacy of existing data and data reporting systems. Variations between service branches are common; inconsistencies occur between services and, within services, between individual hospitals; and data reported are tied to "functional costs" rather than performance requirements.	Volume II pp. 3.1-1 to 58 Volume V pg. 3-1

	Source
• Implement programs to develop automated hospital information hardware and software systems defined by specifications established in the Short Term R&D programs.	Volume II pp. 3.3-12 to 33
• In the area of construction planning, Westinghouse recommends that the DoD develop specific user needs for industrialized building systems, and components throughout BLHC Systems.	Volume II pp. 3.4-1 to 97
• Explore the development of a worldwide health data bank to permit complete assessments of health care trends, the development of preventive medical programs, and to determine health needs and costs on a much more accurate and efficient basis than currently possible. This might be developed jointly by the military services and the Veterans Administration.	Volume III pp. 94 to 101

In summary, Phase I has not only produced tools that have the capability and flexibility for the complete spectrum of DoD hospitals under consideration, but these tools extend the Westinghouse results to far broader applications, such as, retrofit situations.

The many existing BLHC Systems offer a myriad of opportunities for implementation of the results of this systems analysis program. Such retrofits need not wait for the full scale Phase II application for the DoD to realize substantial benefits in time, dollars, and better sub-system operations.

The implications of this study will extend beyond the DoD. As one of the world's largest comprehensive medical health care programs, the DoD BLHC Systems can become a model for large health care systems everywhere.

2. TECHNICAL APPROACH

In preparation for the actual systems analysis, the Westinghouse Team collected and analyzed an immense data resource. The three main resources, printed as separate study volumes, are:

- Data Inventory
- State of the Art
- Medical Health Care Review

These volumes are supported by 33,000 pages of microfilm, sent separately to DoD.

(1) Data Inventory (Volume V) -- a composite of the data gathered from the three primary and six secondary BLHC Systems. The data gathering and work sampling studies were intended to generate the data base for each of the BLHC Systems' functions, and elements, and the flow of all major items (patients, staff, visitor, communications, and materiel) into, out of, and within the system on an inter- and intra-functional basis. The data gathering and work sampling studies were also to be used to identify the highest cost areas of the overall system and, thereby, became the first level of the problem identification.

(2) State of the Art (SOA Volume IV) -- protrayed the most efficient concepts applicable to health care facilities in hardware, management, medical practice, and design and construction, which are currently in use here and abroad. It also portrayed those developments which could potentially be applied after short-term research and development (18 months or less additional work), as well as developments requiring considerable research which would not enter the system until 1975 to 1980.

The state-of-the-art survey, unlike the data gathering and work sampling studies, was not restricted to the BLHC Systems or to military practice only. Moreover, the survey also identified certain improvement contenders in areas not previously identified as problems.

Wherever possible, initial and life cycle costs as well as qualitative evaluations of these concepts have been collected. These data provided the inputs for the cost/benefit analyses, and played a major role in identifying the first level of improvement alternative contenders.

(3) Medical Health Care Review (Volume III) -- recommendations of a team of physicians, on the three primary BLHC Systems. Their primary focus was on attracting, holding, and upgrading personnel; improving facilities in terms of making them more acceptable to medical practice; and making recommendations in the professional services. Their specific observations and recommendations for design and for areas of further study were incorporated into the appropriate project section by the Study Team engineers, architects and systems analysts as the study progressed. For this reason this volume is considered a data resource rather than part of the analysis.

The study outputs of these three data resource volumes represent the most comprehensive set of data which have been generated on the current BLHC Systems as well as on state-of-the-art. They characterize the present system, indicate components which are amenable to improvement, and provide the basis on which to evaluate suggested improvements.

Based on these data resources, the systems analysis study was organized into three major categories: (1) Health Care Planning; (2) Design and Construction of Facilities; and (3) Operations. A fourth major element of the study was Systems Application in which the results of improvement alternatives analyses are demonstrated.

The process of system analysis which was undertaken is as follows:

DEFINE OBJECTIVES

For the first three categories, the first step was to define the system objectives. In the broader sense of the overall study, this objective as defined in the RFQ was to "improve the effectiveness and efficiency of hospital care while reducing costs of operations without lowering the quality of patient care."

This objective is so broadly stated that it was broken into the following major and minor objectives related to each major portion of this study:

- Planning -- generate improved methods and procedures for predicting the health care and patient requirements of the population dependent on a BLHCS both initially and over time. Translate these health care needs into accurate performance requirements to describe the resources needed to meet these needs.
- Design and Construction -- generate improvements to the process of design and construction which will result in a facility in which physical resources can be best applied to meet the demands on the facility at each point in time over the facility's life cycle.
  - (a) The elapsed time from the perception of need for new construction or expansion, to the day of occupancy, should be reduced.
  - (b) Facility must provide predicted health care requirements, yet be as insensitive as possible to prediction errors.
  - (c) Design must be able to absorb major growth without disrupting original facilities.
- Operations -- generate improvement alternatives in the delivery of health care and support services using the best management of available resources. Unless the elements under analysis are critical to other areas, such as clinical labs, the primary goal of these alternatives is to reduce operating costs.

DETERMINE THE MEASURES OF EFFECTIVENESS

The next step was to determine how well each improvement alternative fulfilled each objective. Before discussing specific measures of effectiveness, it is necessary to distinguish between those measures that can be used before the facility is constructed and operating, called prospective measures of effectiveness, and those that can be used only afterwards, called retrospective. Examples

of retrospective measures of effectiveness are the morbidity and mortality rate for the population served, and the ultimate health condition of the patients treated at the BLHCS. In a study such as this, prospective measures are desirable; however, in many areas, especially those related to medical practice, the only practical measures are retrospective.

The measure of effectiveness for planning uses a retrospective and quantifiable measure which is the degree to which the observed demand in the operating facility matches the total demand. Unless the population is measured or sampled, this measure may be invalidated in an undersized facility, which acts to turn away patients and so reduce observed demand. Another measure of effectiveness is the degree to which the translation of resources required to meet the predicted health care need is properly stated to the facilities designers.

For design and construction, nearly all measures of effectiveness for reduced planning time is precisely the time lapse from perception of need to date of beneficial occupancy compared with that which is generally required in the present system. Another measure of effectiveness for the design at initial construction is the degree to which the facility does, in fact, provide for the matching of health care resources with the perceived demands. This measure of effectiveness includes sensitivity to errors in predicted demand. The quantities which can be measured in the operating facility are the flows of patients, staff, and materiel; some of these aspects are quantifiable and some are subjective. The measure of effectiveness of the system's ability to absorb major growth cannot be evaluated until the facility undergoes major expansion. Another example of a prospective measure of effectiveness for design and construction is comparing the estimated first costs of a facility built within this design logic to estimated first costs of similar facilities built using conventional practices. The costs associated with specific changes and growth hypotheses over the life of the facility must then be estimated and compared.

For Operations, most measures of effectiveness are prospective, relating directly to whether the improvement alternative satisfies the objectives

at a reduced cost. "Hard" data was available for most alternatives, and initial and life cycle costs were generated. Where certain alternatives were not amenable to such clear-cut analysis, qualitative measures of effectiveness were used.

Many of the measures of effectiveness relating to the BLHCS are diluted by the impact of uncontrollable variables. For example, policy decisions on the degree to which dependent populations will have their health needs served at the BLHCS will have major impact on the ability of the Department of Defense to properly measure the effectiveness of the planning outputs. The introduction of a Barracks Health Master is another example. This alternative is an operational change in the delivery of health care designed to lighten the load on physicians and on facilities delivering a higher level of health care and lower overall costs. It can be measured as follows:

- lowered costs (which can be documented)
- lowered morbidity and mortality rates evidenced at the higher BLHCS echelons (which may or may not be capable of documentation).

These measures of effectiveness can be documented as cost per military beneficiary to implement this alternative and a documentation of the number of troops seen; a listing of the diseases treated; hours of counseling provided; and possibly the reduction in sick call. However, what is uncontrollable and can adversely affect the application of the entire concept is the personality and education of the individual soldier; the personality and education of the Barracks Health Master; and the support, or lack of it, given this concept by the higher levels of medical health care professionals within the BLHC System. Such uncontrollable factors have been considered in each of the specific analyses which follow.

SYNTHESIZE ALTERNATIVES

For each major element of the existing BLHC System, the present operating method was characterized, quantified, and defined to the degree of specificity possible. In each case, the present method and its costs and resource utilizations

were considered as the first alternative. Study efforts were then focused on those areas with the largest cost or resource utilization elements, in which improvements would contribute the greatest overall benefit to the system or in those areas where throughput capability is more important than cost.

Improvement alternatives from the state-of-the-art survey were then matched to comparable elements in the current system to determine whether a single alternative or a combination of alternatives could improve upon the present system. Where several alternatives offered promise over the current method, detailed studies were initiated to systematically characterize the nature of these alternatives in relation to their reaction to various patient mixes; scale effects; and costs in labor and supplies. Where improvement alternatives were not available from within the state-of-the-art, various groups within the study team developed new concepts and tools which could be introduced as improvements to the current method of operation. Only concepts and tools which were both feasible and economical were developed.

ANALYSES OF ALTERNATIVES

After the major improvement alternative contenders were identified or created in each major study area, they were subjected to an analysis process that varied according to the complexity and number of alternatives examined. In most of the analyses, life cycle cost analysis ranked the alternatives. In these analyses the impact of decisions made in the present is gauged by the "present value method". This method normalizes the effect of inflation in labor and equipment costs by discounting the present money spent in the future.

In addition to the quantitative cost effectiveness or cost/benefit analysis, the alternatives were subjectively evaluated by health care professionals and experts in numerous other fields. In a few areas, only subjective evaluations were possible. The subjective evaluations, such as efficiency, safety, and personnel utilization, are expressed in the individual analyses in several ways. In some cases, the degree to which an alternative satisfies the subjective

objectives is listed. In a few, the alternatives are given a subjective ranking with pertinent differences described.

The interaction of improvement alternatives in different functions and areas was also evaluated. For example, if an improvement alternative in one area diminishes the effectiveness of or precludes an improvement alternative in another area, the effect must be included in the cost-effectiveness analysis. These interactions have been both quantifiably and subjectively analyzed. The fine detail of data collected was essential to quantification of interactions between improvement alternatives.

SENSITIVITY ANALYSES

Within the analyses, alternatives were evaluated for a range of variables, such as workload and economic factors, to see what degree of error in prediction can be tolerated before the recommendations are invalidated. This process of testing is called sensitivity analysis. Each recommended improvement alternative was tested in this manner.

The following sections of the Systems Analysis all follow the above procedure:

- Planning
- System Design Concept
- Operational Sub-system Analysis

In the final section, Systems Application, the results of the analysis are tested. Hypothetical base population and mission have been defined with assigned life cycle characteristics. The results of this systems analysis has produced the performance requirements, operational objectives, and general design concepts for the NGMH.

3. PRESENTATION OF RESULTS

3.1 PLANNING

3.2 SYSTEMS DESIGN CONCEPTS

3.3 OPERATIONS ANALYSES

3.4 SYSTEMS APPLICATION

3.1 PLANNING

INTRODUCTION

Planning, as defined in this study, is the prediction of patient care requirements and the resources which must be allocated to ensure their satisfaction. Total patient care requirements, which are independent of BLHCS services and facilities, are composed of demand and utilization. Demand can be defined in units of inpatient admission and outpatient visits and utilization as bed occupancy and ancillary usage. Health care resources to match these requirements include organizational and functional structures of services, facilities and operations. Although planning and design are dealt with separately in this study, they are sequential steps and do not imply the necessity for any organizational division.

Methodologies and techniques for predicting patient care requirement averages over a long term have been emphasized in order to lay the foundation for facilities design. To predict patient care requirements, facilities presently administering care must be studied. Medical technology and practice vary from one BLHC System to another, especially in the fine detail of expenditure of health care resources. Therefore, to produce meaningful data, we have limited the level of detail in which we have characterized patient care requirements.

In the remainder of this section the BLHC System is characterized briefly by mission, scope of services, and population served. Measures of effectiveness are discussed for predicting patient care requirements, followed by an evaluation of the planning method required by present DoD guidelines, i.e., historical workload. A more effective planning method which predicts patient care requirements based on population projections is then proposed. This method, which appears to have advantages over historical workload as a method of predicting patient care requirements is embodied in a set of linear transformations called the "Demand Model." The numbers generated for the Demand Model demonstrate its feasibility. Moreover, the generality of the methodology is such that the numbers can be updated and refined without invalidating it.

BLHC SYSTEM CHARACTERIZATION

The primary mission of a BLHC System is to render medical care to members of the U.S. Armed Forces; the secondary mission is to render care to dependents of Armed Forces personnel. Retired personnel and dependents of retired or deceased personnel are authorized for care and are treated to the

extent resources are available. Although other members of the Public Health Service and visiting military personnel of allied nations are also authorized for limited care, they absorb such a small fraction of the health care resources at a BLHC System that their requirements are not discussed here.

The BLHC System is a comprehensive health care system which includes preventive medicine and entry point care, termed first echelon care, and short-term hospitalization, termed second echelon care. Some BLHC Systems may also serve as specialty and regional referral centers for diseases or conditions requiring special facilities. Unlike many civilian institutions, long-term care for chronic or disabling conditions is not a mission of the BLHC System.

Each of the four primary beneficiary groups has distinguishing characteristics which sets it apart from the others, both in its predominant demands and in some administrative features of the care each receive.

- Active duty members of the U.S. Armed Forces are predominantly young males. Because these people are screened before induction, incidences of disabilities or chronic illnesses are low. Their most common illness is the common cold. Enlisted recruits, because of unaccustomed stress during training, create a heavy load on the BLHC System for sick call.
- Since dependents of active duty personnel are predominantly young females, infants, and children, their demands are mostly for obstetrics and gynecology, and pediatric services.
- Retired personnel are generally subject to the ills of middle age.
- Dependents of retired or deceased personnel are older females and teen-aged children.

The five most prevalent causes of inpatient admissions for each of these beneficiary categories is shown in Table 3.1-1, as derived from USAF Medical Record Summary Sheets for CY67 (see Appendix 3.1-1 for details of the data processing).

To furnish a basis for comparison of illness rates across health care systems, age-sex distributions of these beneficiary categories were found (Figures 3.1-1 to 3.1-4). To derive these distributions it is assumed that each age-sex cohort of the dependent categories have admissions under CHAMPUS proportional to those of the U.S. civilian population (see Appendix 3.1-2). Only the age-sex

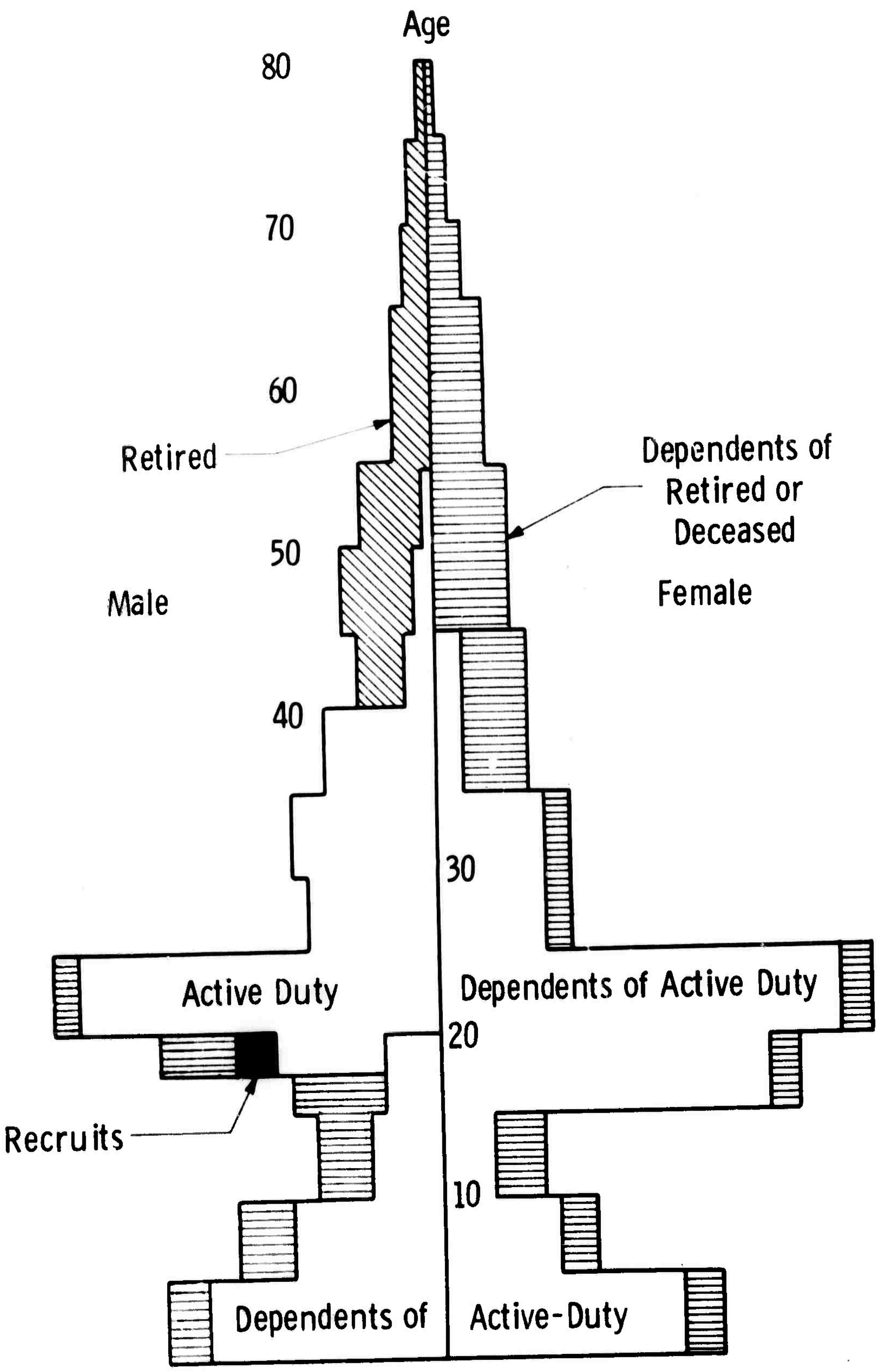
TABLE 3.1-1

MOST PREVALENT MAJOR ICDA DIAGNOSES (PRIMARY)

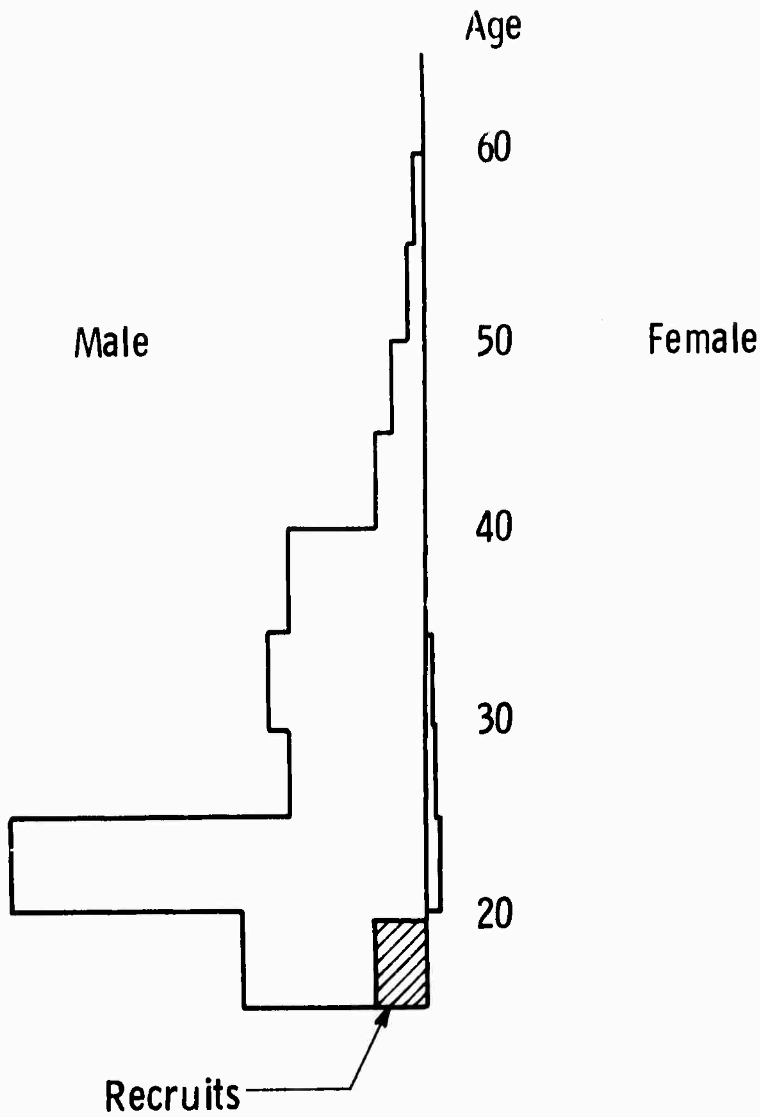
BY BENEFICIARY TYPE*

Beneficiary	DOC	% of Admissions of that B. T. to Air Force Hospitals in CONUS
Recruits		
	8-Respiratory System	23.7
	1-Infective & Parasite	11.4
	5-Mental & Personality	11.0
	9-Digestive System	10.5
	12-Diseases of the Skin	10.3
Active Duty Personnel		
	9-Digestive System	14.7
	17-External Causes	14.2
	8-Respiratory System	11.2
	16-Ill-defined Conditions	10.2
	13-Diseases of the Bones	7.6
Dependents of Active Duty Personnel		
	11-Deliveries	26.8
	18-Births and Special Admissions	23.5
	10-Genitourinary System	8.1
	3-Respiratory System	6.9
	16-Ill-defined Conditions	5.9
Retired Personnel		
	7-Circulatory System	18.6
	9-Digestive System	17.1
	2-Neoplasms	9.8
	16-Ill-defined Conditions	9.3
	10-Genitourinary System	7.2
Dependents of Retired or Deceased Personnel		
	10-Genitourinary System	15.4
	9-Digestive System	10.4
	2-Neoplasms	9.4
	16-Ill-defined Conditions	8.6
	17-External Causes	7.7

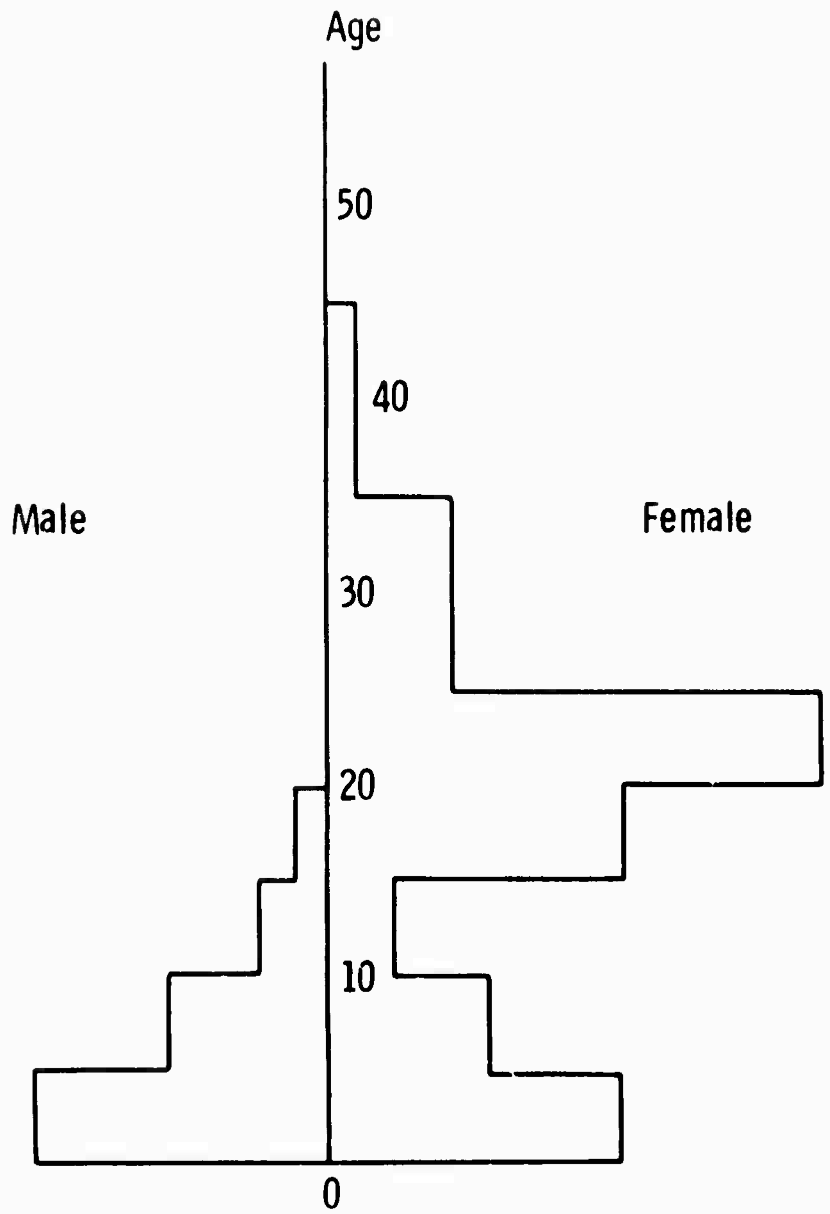
* Source: Medical Record Summary Sheets, CY1967, USAF.



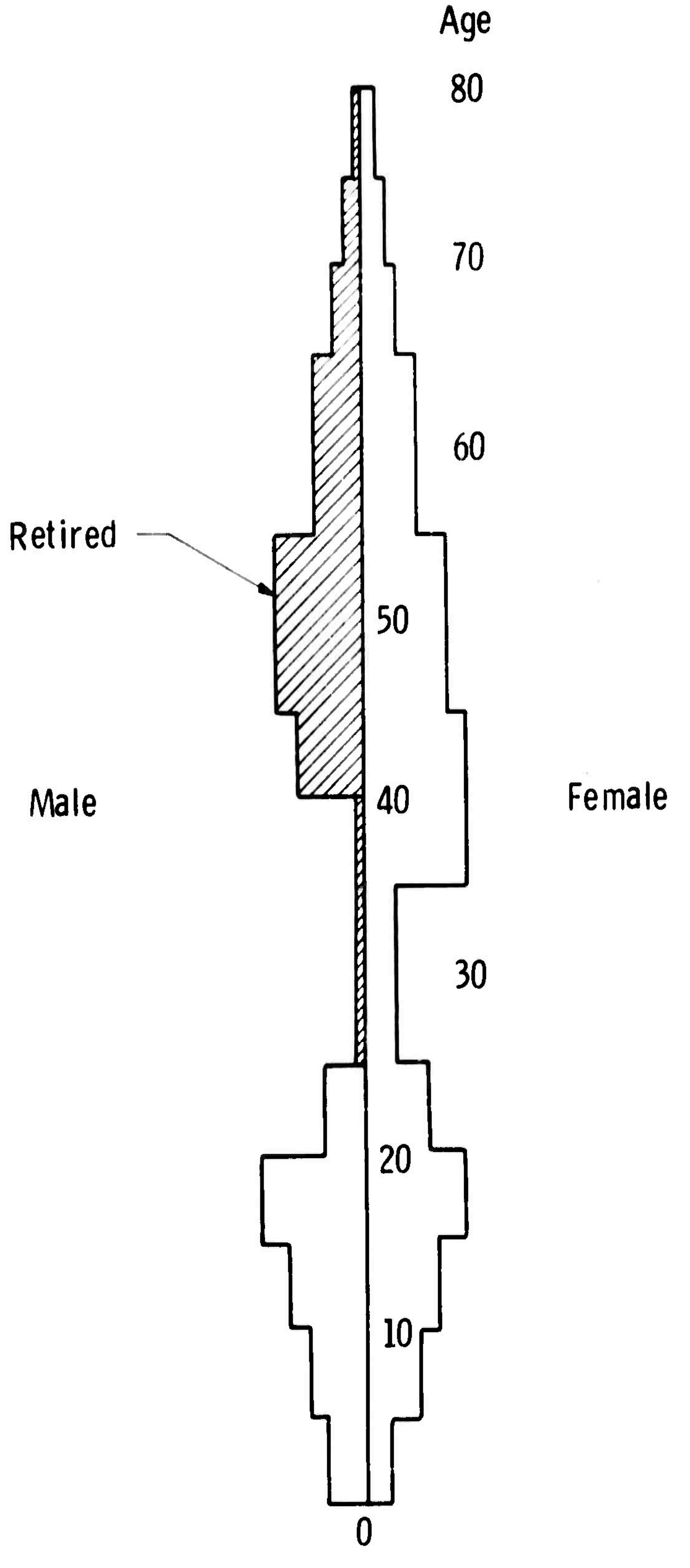
Age-sex distribution:
Fig. 3.1-1—Total BLHCS population



Age-sex distribution:
Fig. 3.1-2—Active duty population



Age-sex distribution:
Fig. 3.1-3—Dependents of active-duty population



Age-sex distribution
Fig. 3.1-4—Retirees and dependents of retired or deceased population

distributions are derived, not total numbers of dependents (which are known from other sources).

The age-sex distribution (world-wide) of active duty personnel is from the USAF Biostatistical Report for 1967. The age-sex distribution of retired personnel (excluding Title III retirees) was taken from a chart prepared by OASD (Office of Manpower and Reserve Affairs). The age-sex distribution of the dependent categories applicable in CONUS were derived from an age-sex breakdown of inpatient admissions in CONUS under the CHAMPUS program (CHAMPUS Twelfth Annual Report) and from U.S. admission rates by age and sex (Health Interview Survey, Department of Health, Education and Welfare).

MEASURES OF EFFECTIVENESS

Patient care requirements depend both on the demand on the BLHC System and on the utilization of health care resources to meet these demands. Errors in predicting patient care requirements may result from error in predicting demand, even if utilization per outpatient visit or per admission is as predicted. Conversely, changes in medical practice or technology will change the patient care requirements even with demand remaining constant. Demand and utilization are separate problems; they can be predicted independently and measured nearly independently.

The only sure, quantitative measures of effectiveness for planning are retrospective: how close the observed is to the predicted. Such ex-post facto measures, however, must be supplemented by the following qualitative criteria which allow a planning method to be assessed before it is implemented: 1) does the method allow prediction, 2) is it rational, and 3) is it feasible.

EVALUATION OF HISTORICAL WORKLOAD

The present DoD method for determining future patient care requirements is average workload over a previous 12-month period.[1] This section will assess this planning method.

Because the planning estimates of patient care requirements at the nine study BLHC Systems were not available during the study, retrospective evaluation was not possible. Consequently, the study Systems and parts of the military health care system in CONUS have been assessed on how closely the demands of

1. DoD Instruction 6015.17 Par. V.C.3, 24 September 1968.

the beneficiaries are met by resources at the BLHCS.

Since the primary mission of the BLHC System is to provide health care for military personnel, we assume that all military health care demands are being met. Statistics on their demands on the study Systems are assumed to accurately reflect these demands. The following analyses, however, show that the non-military beneficiary demand is not entirely met by the BLHC Systems and that the method of historical workload permits this condition to persist indefinitely, i.e. inadequate resources and services provided under CHAMPUS.

Two analyses were performed on the demands at the BLHC Systems studied. In each, the BLHC Systems have been considered a sample from a statistical universe of military health care systems in the continental U.S. The limited number of study BLHCS excluded inter-service comparisons. In the first analysis, outpatient visits and inpatient admissions per member of the population were plotted as a function of time from 1965 to 1968, using the data pack information (Figures 3.1-5 and 6). Beneficiary categories were not broken out since the data pack did not contain this information. The data pack information on Walson Army Hospital did not permit this analysis. Aggregate admissions and outpatient visits show no particular trend at any individual base, but do show substantial variation in services per person rendered at the bases.

A second, more detailed study was performed to find outpatient visits and inpatient admissions per person by beneficiary category for 1968 at the BLHC Systems studied (Figures 3.1-7 through 15). Since only the demands from the population served by the BLHC System were desired, transfers into the BLHC System and IRHA (injured as a result of hostile action) were not included in inpatient admissions. The planning process for a BLHCS includes the estimated health care resource usage of these patients, however the objective is to describe the services provided the populations at the BLHC Systems. Dispensary visits by non-military beneficiaries were included in outpatient visits; dispensary visits by military personnel are considered separately from outpatient visits. Figures for Air Force dispensary visits are taken from reporting dispensaries. Recruits were not distinguished from extended active duty personnel on these forms.

The main sources of data were: Army, DA 8-268 (Morbidity Reports), and DD 444 (Outpatient Report); Navy, NAVMED 1454 (Medical Services Report); Air Force, AF 235 (Report of Patients). Recruits were not distinguished from extended active duty personnel, on these data sources.

The figures for population served were taken from the data pack. These figures were updated, when possible, during the data collection; in some cases the data pack population figures were only estimates based on nationwide ratios. The detailed figures for each BLHC System are shown in Appendix 3.1-3.

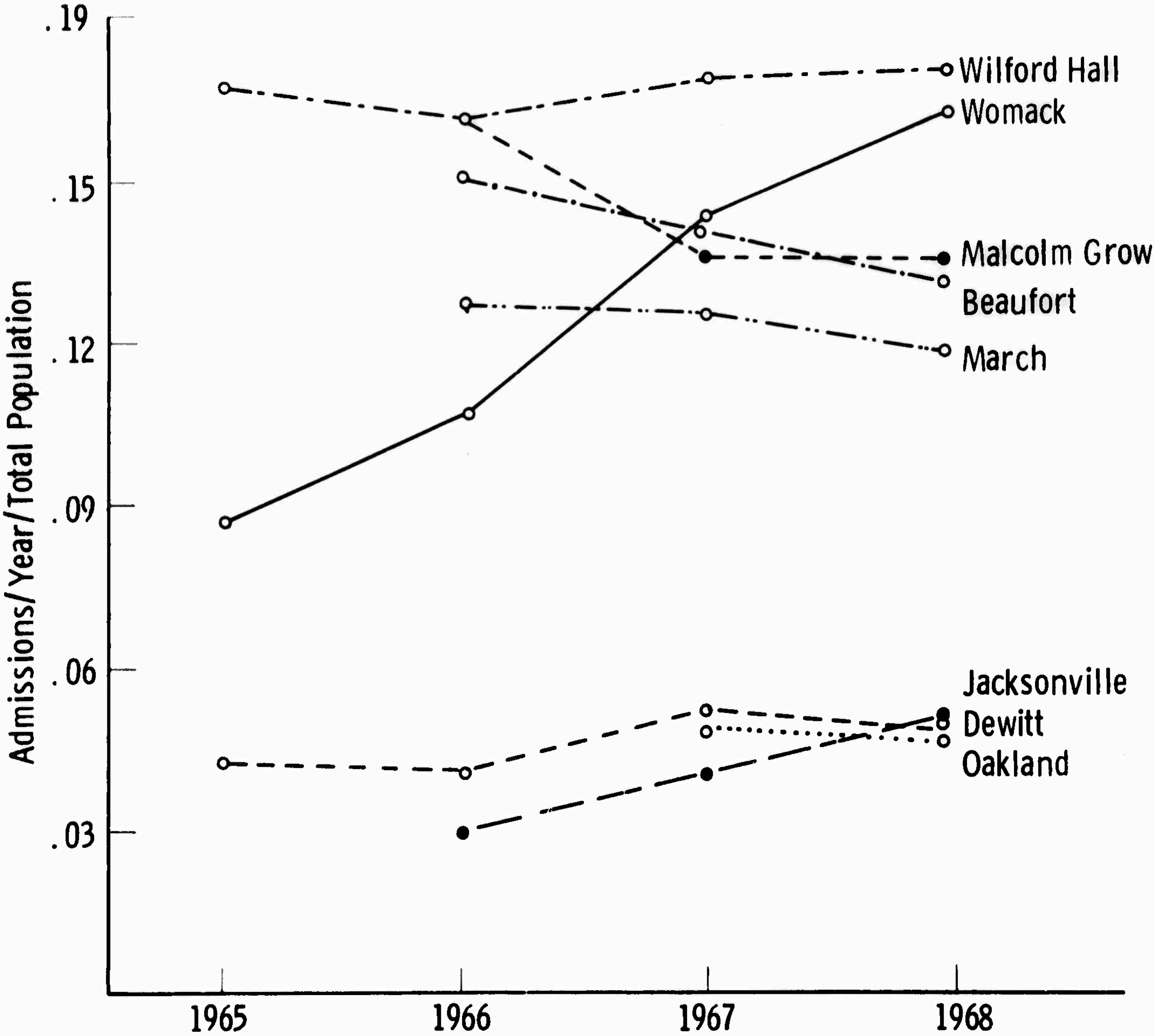


FIGURE 3.1-5. ADMISSIONS PER YEAR PER TOTAL POPULATION (FY1965-68)

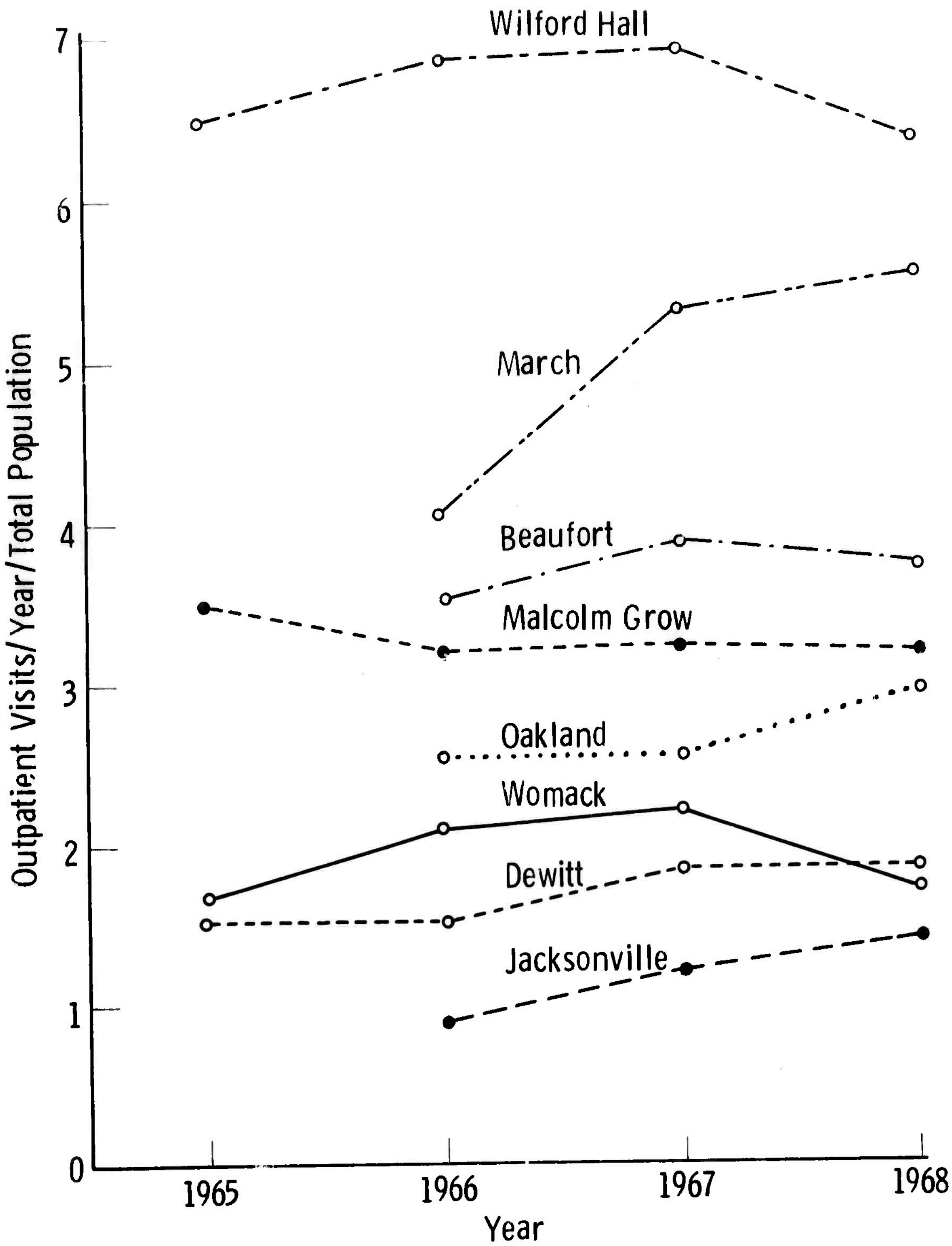
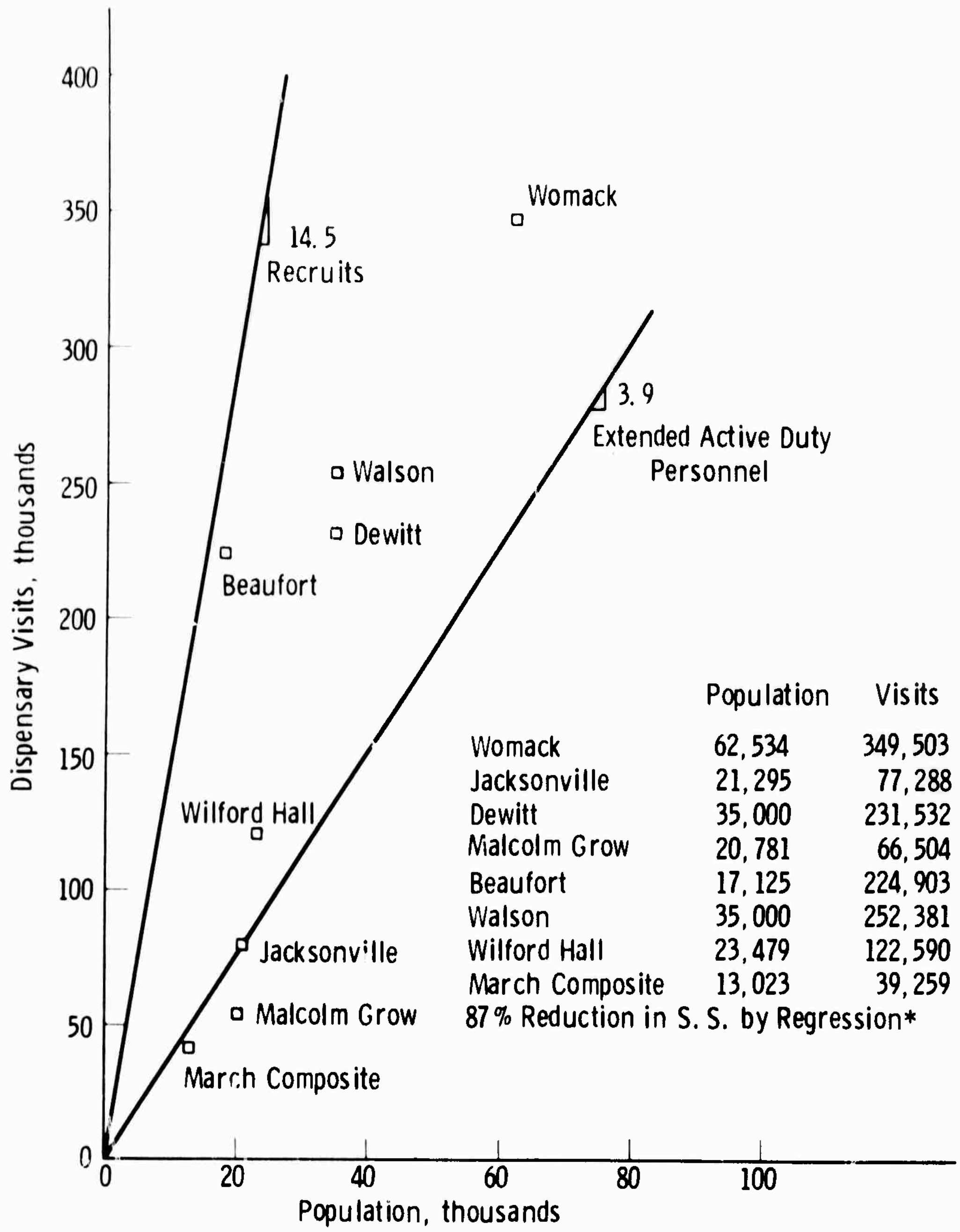


Fig. 3.1-6—Outpatient visits per year per total population for FY 1965-1968



	Population	Visits
Womack	62,534	349,503
Jacksonville	21,295	77,288
Dewitt	35,000	231,532
Malcolm Grow	20,781	66,504
Beaufort	17,125	224,903
Walson	35,000	252,381
Wilford Hall	23,479	122,590
March Composite	13,023	39,259

87% Reduction in S. S. by Regression*

Fig. 3.1-7 – Dispensary visits vs population of military personnel

*Reduction in SS (%) = 100 $\left[1 - \frac{\sum (y - \hat{y})^2}{\sum y^2}\right]$

where y = sample value
$\hat{y}$ = regression value

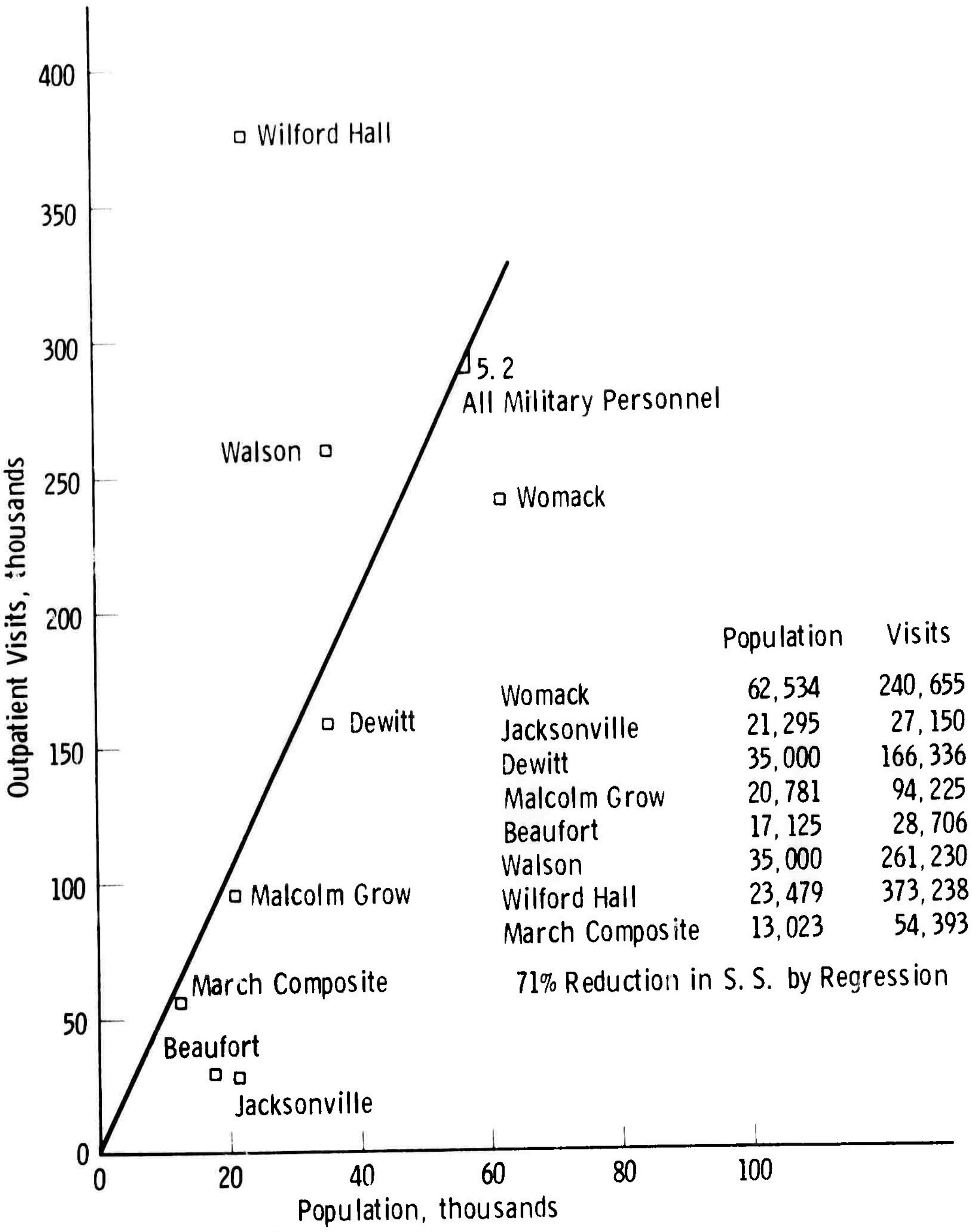


Fig. 3.1-8—Outpatient visits vs population of military personnel

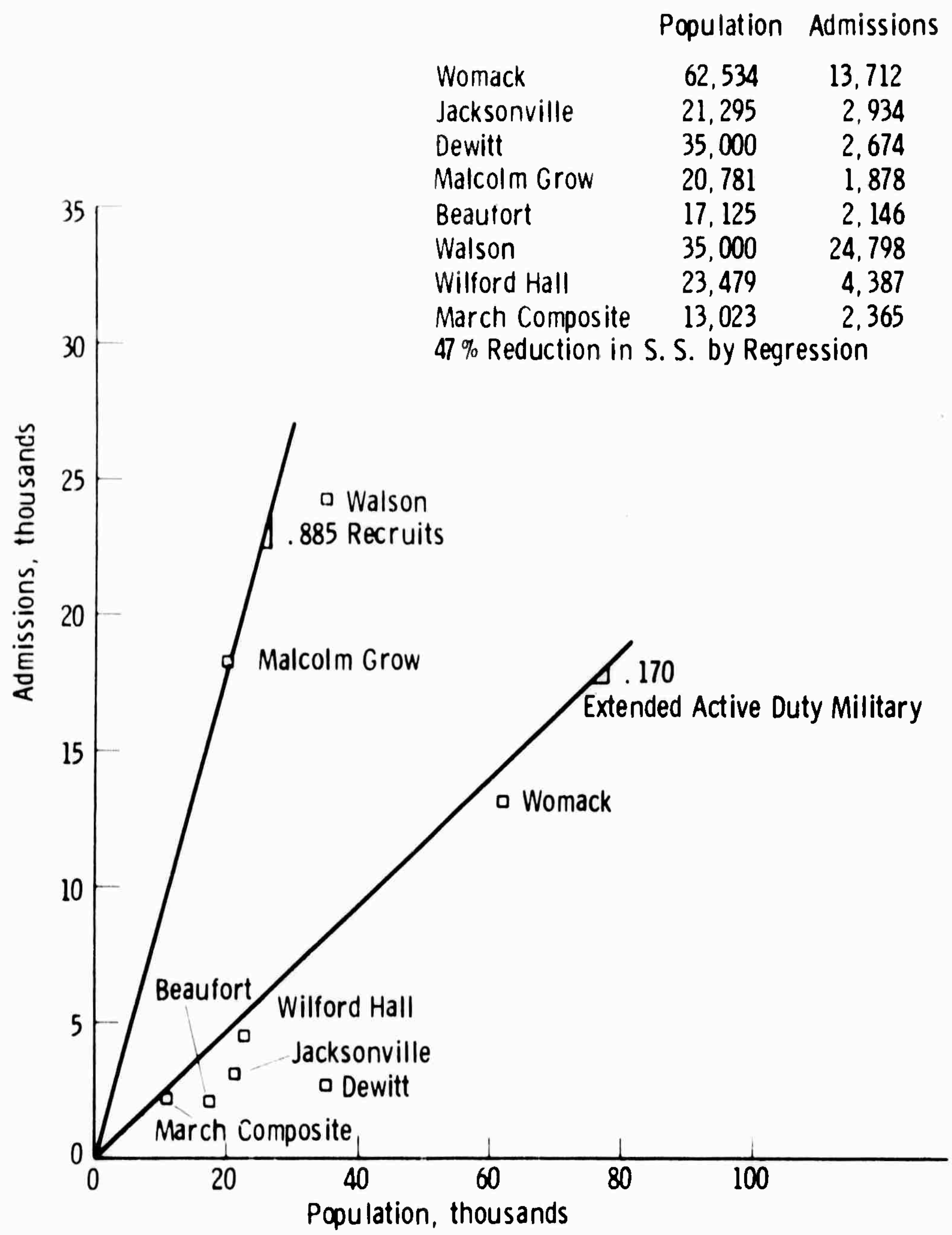


Fig. 3.1- 9-Admissions vs population of military personnel

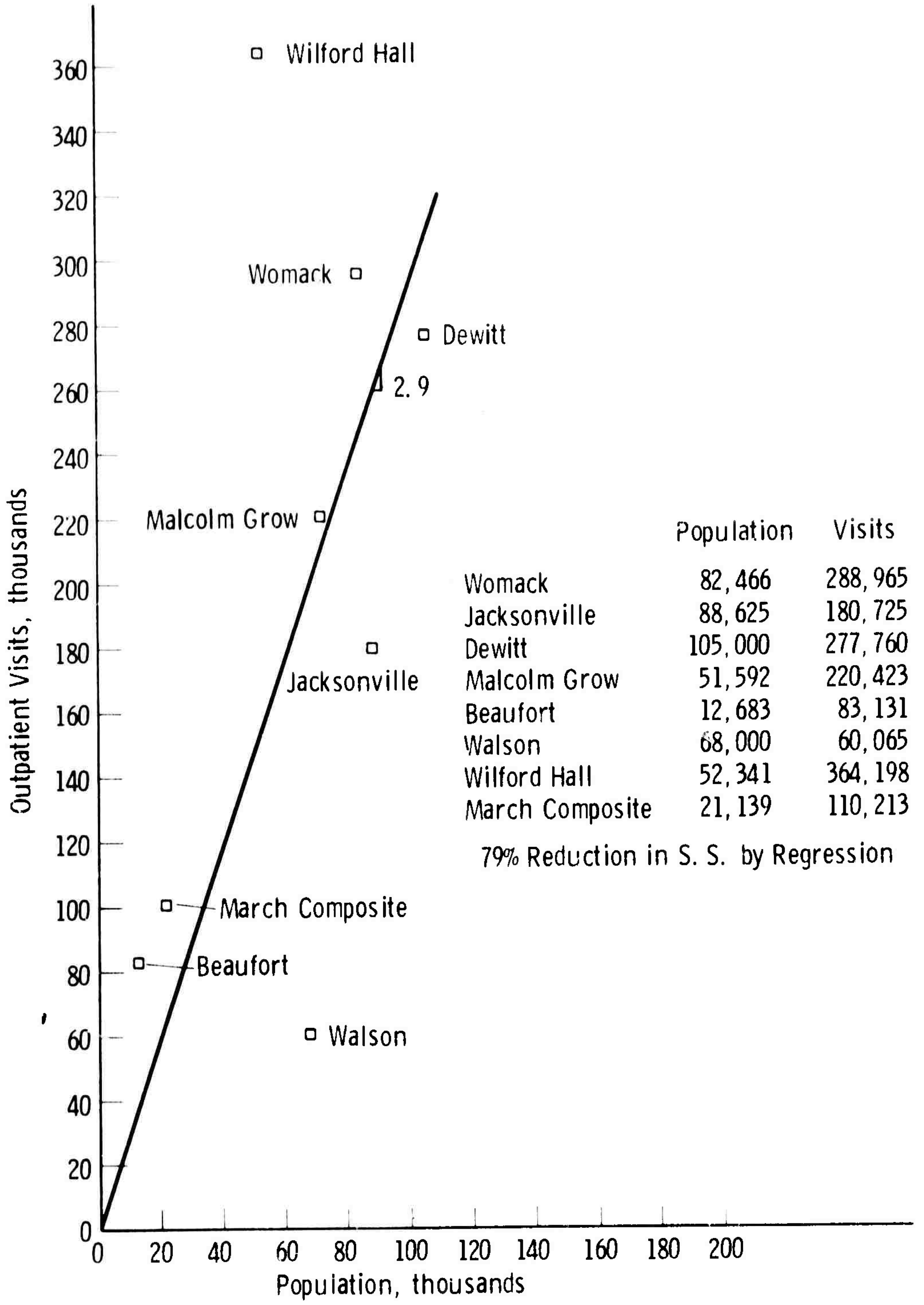
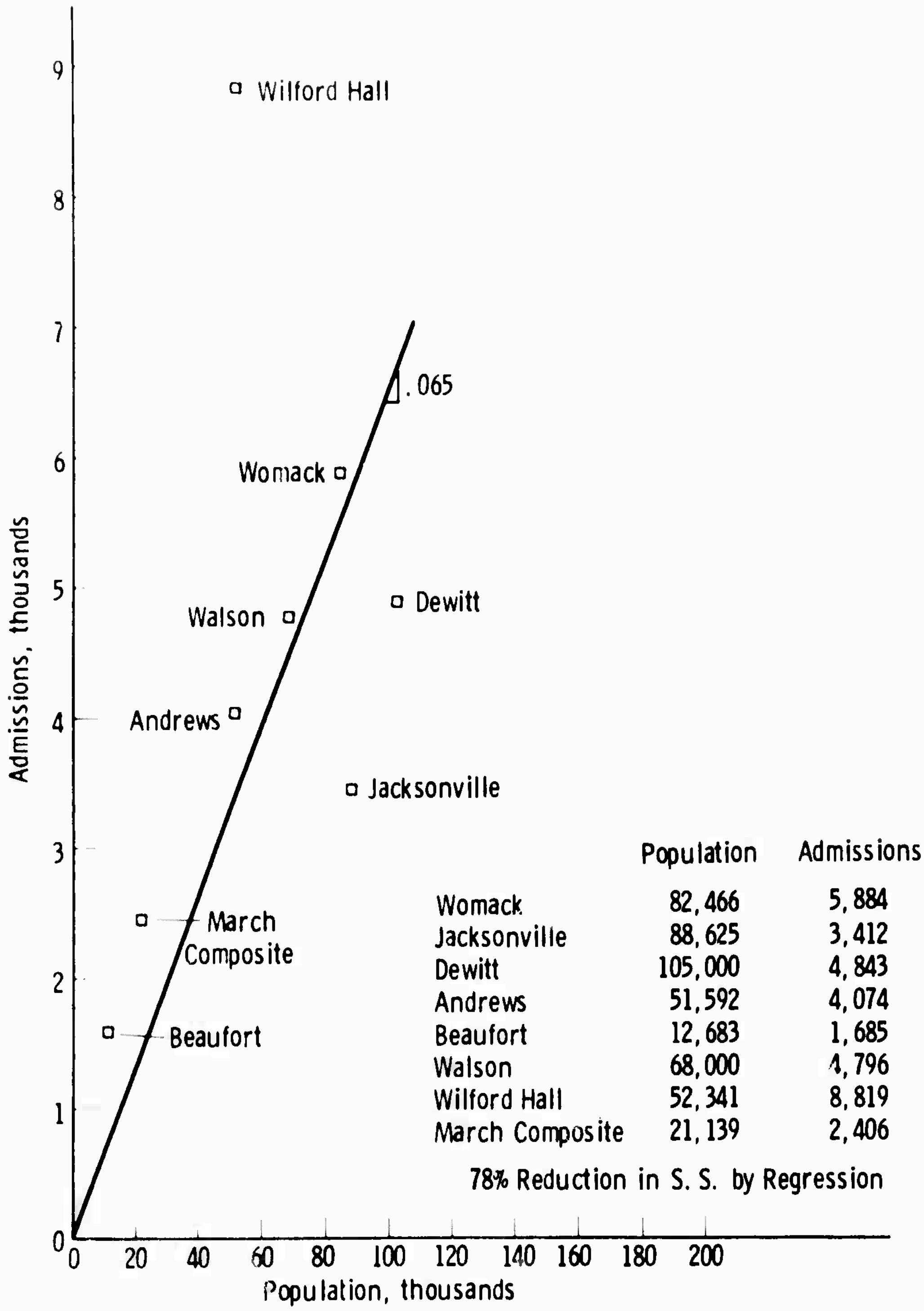
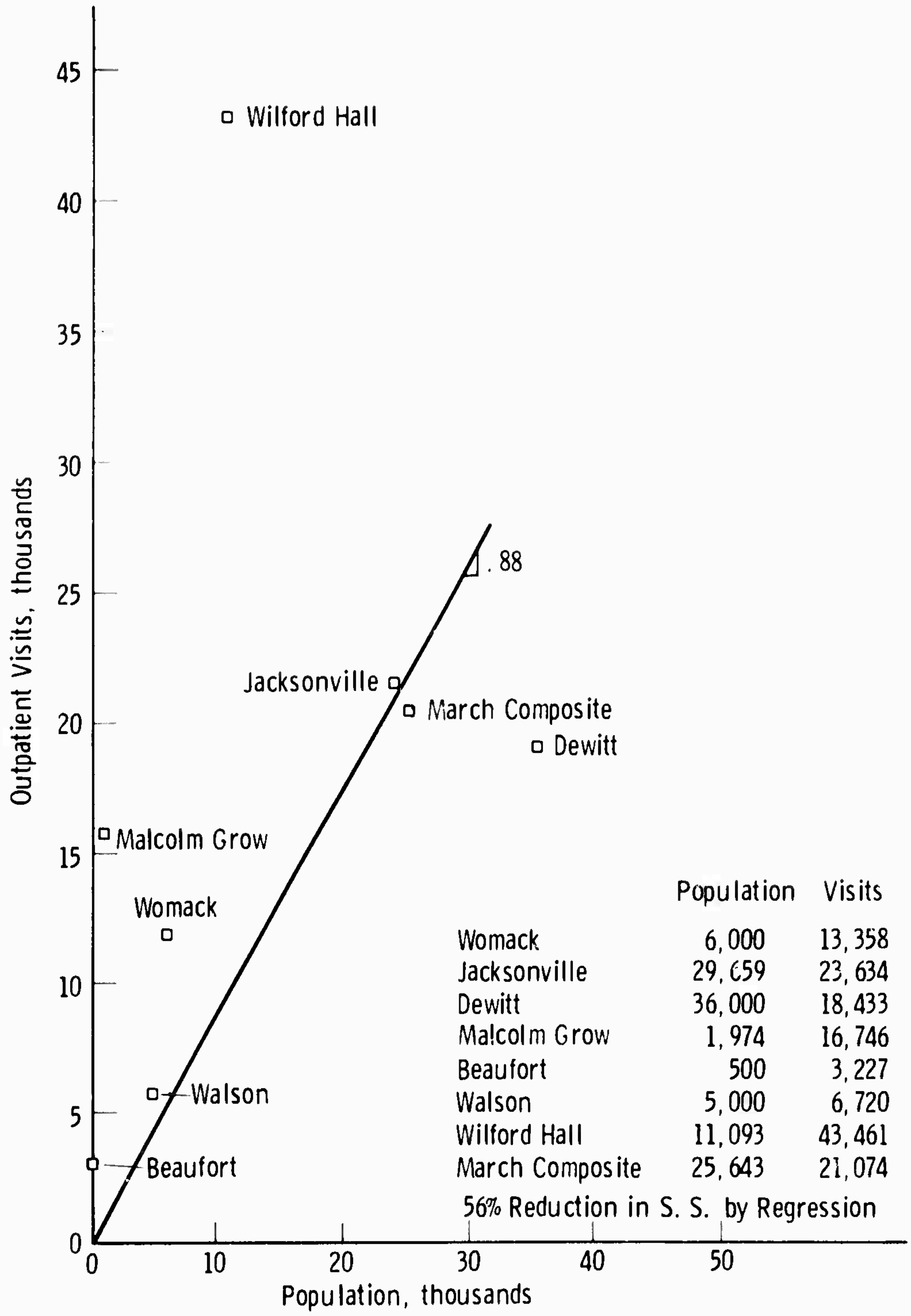


Fig. 3.1-10—Outpatient visits vs population of dependents of active duty personnel



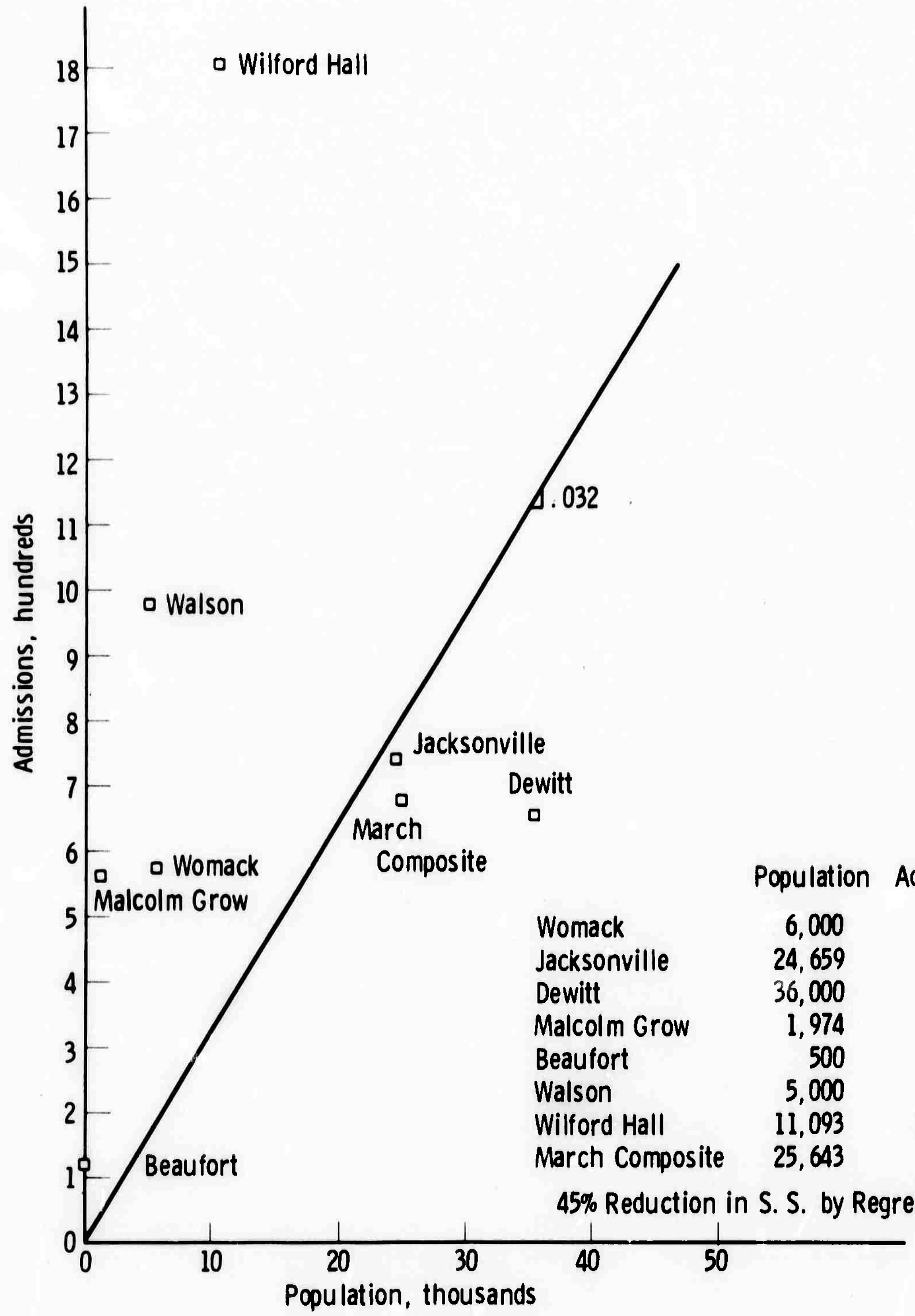
	Population	Admissions
Womack	82,466	5,884
Jacksonville	88,625	3,412
Dewitt	105,000	4,843
Andrews	51,592	4,074
Beaufort	12,683	1,685
Walson	68,000	4,796
Wilford Hall	52,341	8,819
March Composite	21,139	2,406

Fig. 3.1-11—Admissions vs population of dependents of active duty personnel



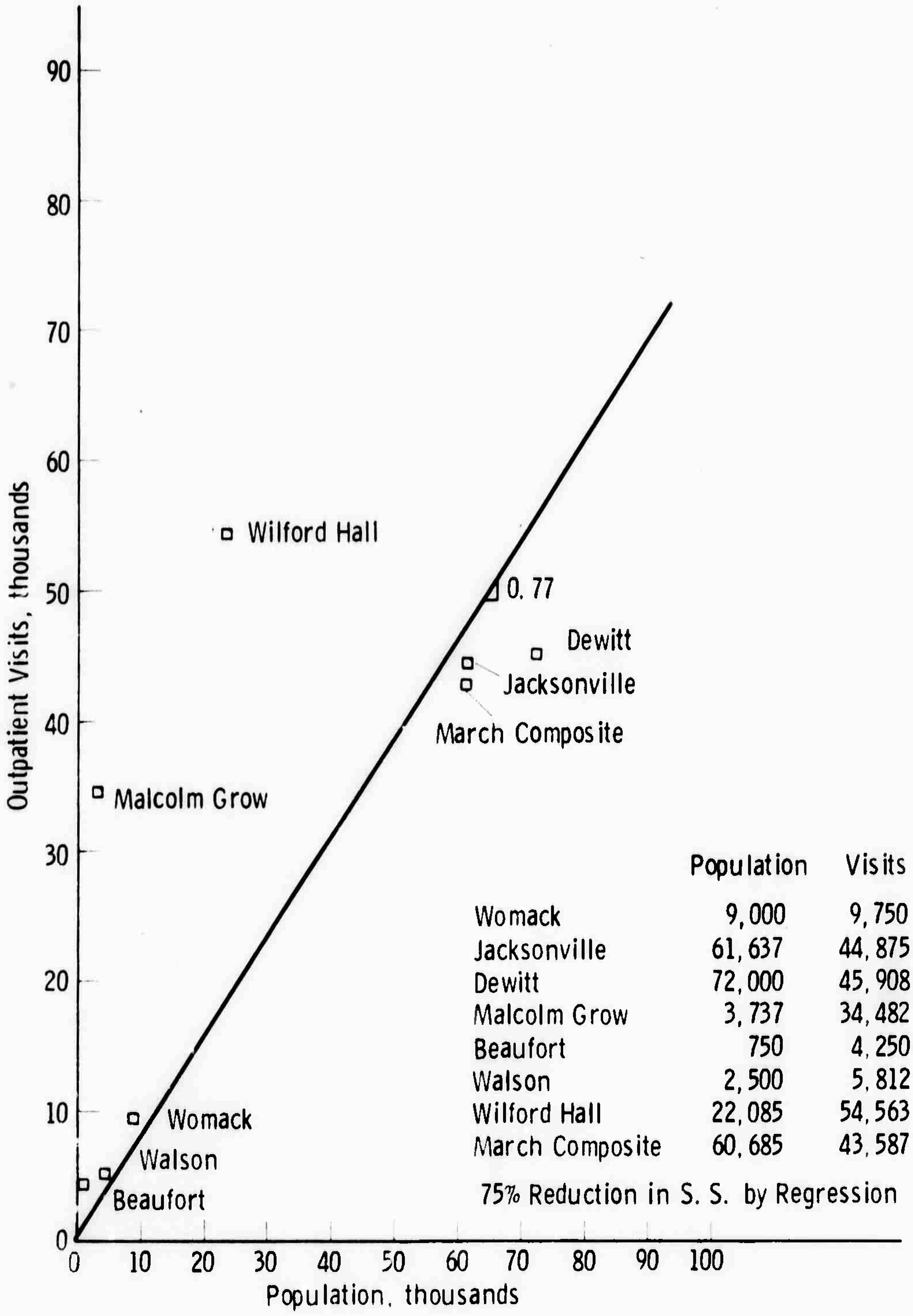
	Population	Visits
Womack	6,000	13,358
Jacksonville	29,659	23,634
Dewitt	36,000	18,433
Malcolm Grow	1,974	16,746
Beaufort	500	3,227
Walson	5,000	6,720
Wilford Hall	11,093	43,461
March Composite	25,643	21,074

Fig. 3.1-12—Outpatient visits vs population of retired personnel



	Population	Admissions
Womack	6,000	581
Jacksonville	24,659	746
Dewitt	36,000	658
Malcolm Grow	1,974	577
Beaufort	500	122
Walson	5,000	971
Wilford Hall	11,093	1,815
March Composite	25,643	675

Fig. 3.1-13—Admissions vs population of retired personnel



	Population	Visits
Womack	9,000	9,750
Jacksonville	61,637	44,875
Dewitt	72,000	45,908
Malcolm Grow	3,737	34,482
Beaufort	750	4,250
Walson	2,500	5,812
Wilford Hall	22,085	54,563
March Composite	60,685	43,587

Fig. 3.1-14 – Outpatient visits vs population of dependents of retired or deceased personnel

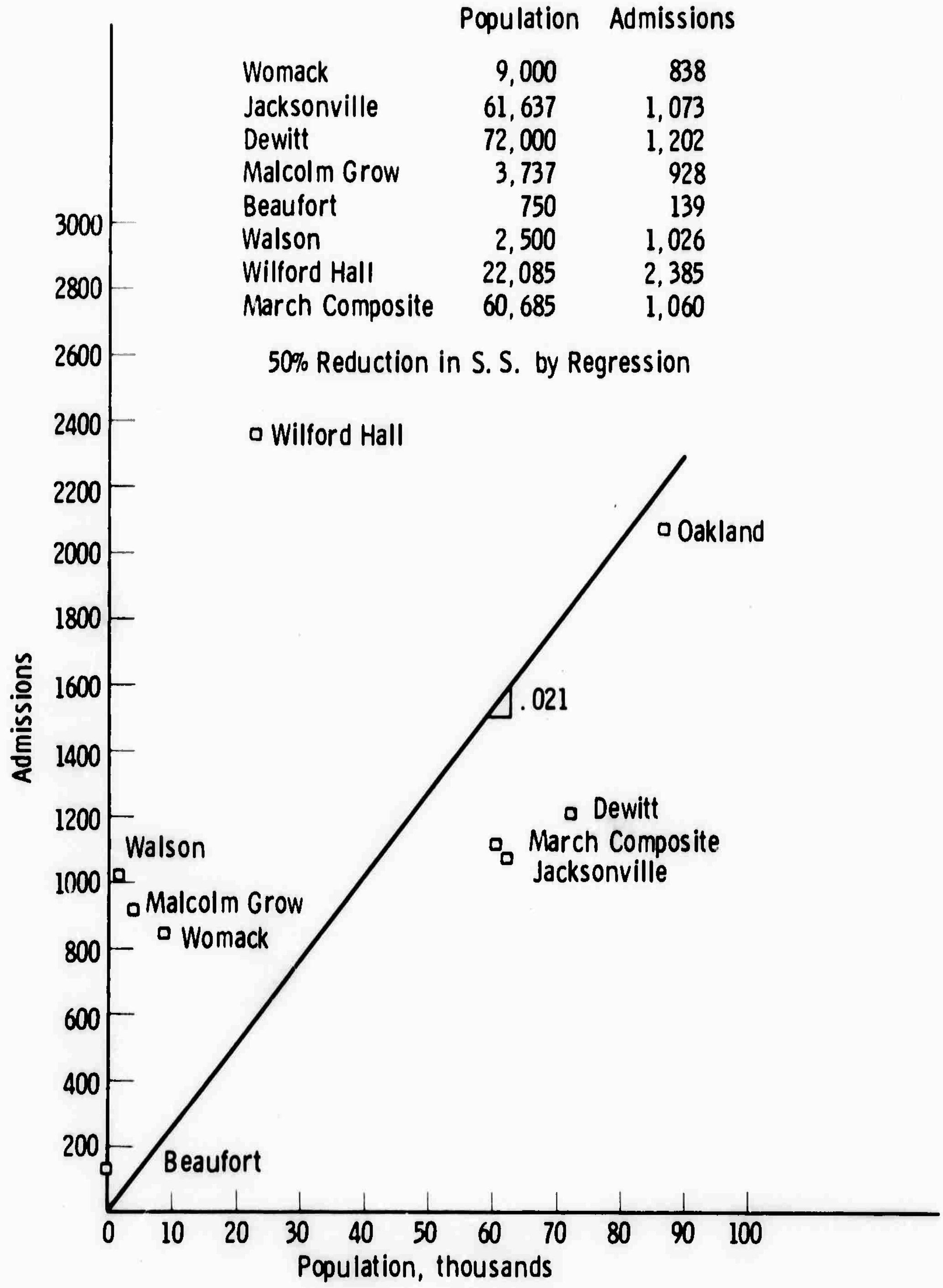


Fig. 3.1-15—Admissions vs population of dependents of retired or decesed personnel

Oakland Naval Hospital is omitted from the analysis because the required data were not available. On each figure is shown the least-squares fit straight line(s) through the origin. To separate the component due to recruits from that of extended active duty personnel, regression analysis was used.

The results for military personnel at these BLHC Systems are:

(1) On the average, recruits visit dispensaries approximately 3-1/2 times as often as active duty personnel per exposure year (14.5 visits per year versus 3.9 visits per year). At Parris Island, data collection showed that recruits' visits are 16.6 per year.

(2) On the average, recruits are admitted as inpatients approximately 5 times as often as active duty personnel (890 per 1000 versus 170 per 1000 admissions per year). There was a wide variation in admission rates of the recruit population in each of the services. This is caused by types of training being performed, regional factors, and dispensary operation and services rendered.

(3) Keeping recruits and extended active duty personnel as separate categories, partial regression coefficient for recruits was nearly zero. Consequently, the best fit regression line, on Figure 3.1-8 5.2 visits per year, is for the two groups combined.

These results indicate the large differences in demands between recruits and extended active duty military personnel and justify predicting their patient care requirements separately.

The results for the non-military beneficiaries which did not include services rendered under CHAMPUS, show that at these BLHC Systems:

(1) Dependents of active duty personnel have approximately 3/4 as many outpatient visits per year as the U.S. civilian population (2.9 versus approximately 4 per year U.S. national average in 1968).

(2) Dependents of active duty personnel are admitted approximately 1/2 as often as the U.S. civilian population (65 per 1000 versus 137 per 1000 per year average U.S. admission rate 1968).

(3) Demands due to retired personnel and dependents of retired or deceased personnel are generally lower than might be expected, by comparison with civilian statistics, and do not correlate well with the estimated populations. This result may be due either to inaccuracies in estimating

population or to the availability of other means of receiving health care.

These results for eight of the study BLHC Systems lead to the suspicion that some of the health care demands of the non-military beneficiaries are being met outside the BLHC System. It is not possible from these results to definitely state that any particular BLHC System is not meeting the health care demands of its beneficiaries, since data on the demands at a particular BLHCS which were served in other health care systems, such as CHAMPUS, could not be found.

The Civilian Health and Medical Program of the Uniformed Services (CHAMPUS) augment the BLHC System by providing benefits for health care services to authorized dependents of active duty personnel, retirees, and dependents of retired or deceased personnel[1, 2]. For ambulatory care, beneficiaries choose freely between a BLHC System and services in civilian facilities.[3] To be hospitalized under the CHAMPUS program, dependents of active duty personnel who reside with their sponsor require a certificate of non-availability from the BLHC System; other beneficiaries have free choice. In CY68 , approximately 71 % of dependents of active duty personnel did not reside with their sponsor, and so had free choice.

Though the BLHC System maintains records of non-availability slips, the large fraction of beneficiaries who have free choice makes their interpretation difficult. Records on CHAMPUS claims are maintained at a state-wide level by the program's contractors. Thus, an individual BLHC System has little idea of the demand in the vicinity of the base that is served under CHAMPUS.

However, it is possible to compare total CONUS inpatient claims processed and approved under CHAMPUS with total inpatient admissions in the

[1] CHAMPUS Twelfth Annual Report, 1 June 1969.

[2] Columbia University School of Public Health and Administrative Medicine, "Military Medicare," June, 1969, study sponsored by the Department of Defense.

[3] Dependents residing on base must use its resources unless needs cannot be met locally.

military health care system in CONUS. With this comparison, it is possible to extrapolate approximate measurements of health care demands for dependents and retirees. Since retirees and dependents of retired or deceased personnel over 65 may choose between a BLHC System, CHAMPUS, or MEDICARE, and retirees may be covered under private insurance plans provided by an employer, the totals for these groups from CHAMPUS and the military health care system will be less than the total health care demands.

Since many comparatively low cost outpatient visits are not reported because of deductibles and coinsurance, the reported number of outpatient visits does not accurately reflect demand. Therefore, this analysis will be confined to inpatient admissions.

Table 3.1-2 shows total inpatient admissions in the CONUS military health care system and inpatient admissions under CHAMPUS. The figures for populations of military personnel and their dependents are world-wide. The figures for retirees and dependents of retired or deceased personnel are for CONUS. Data sources are indicated at the bottom of the chart. The apparent admission rates shown are the total admissions under CHAMPUS and in the CONUS military health care system divided by total persons in the population. The expected admission rates were derived under the assumption that the non-military beneficiaries have for each age-sex cohort an admission rate equal to that of the U.S. civilian population. The age-sex distributions of the non-military beneficiaries were used together with statistics from the National Center for Health Care Statistics, HEW, to derive the expected admission rates (see Appendix 3.1-4 . Since the world-wide number of dependents of active duty personnel was used, the actual admission rate is approximately 10% higher than that shown here.

The apparent admission rate of dependents of active duty personnel to the assemblage of CONUS BLHC Systems is higher (86/1000) than the study hospitals (65/1000). For retirees, the inpatient admission rate to CONUS BLHC Systems is higher (75/1000) than in the eight study BLHC Systems (32/1000). CONUS-wide and at eight study hospitals the inpatient admissions to the BLHC System are far lower than civilian admission rates.

TABLE 3.1-2

INPATIENT ADMISSIONS IN MILITARY HEALTH CARE SYSTEM AND CHAMPUS
FOR FY69, EXCEPT WHERE NOTED

BENEFICIARY	POPULATION ($x10^6$) USA	USN	USAF	TOTAL	ADMISSIONS ($x10^5$) USA	USN	USAF	TOTAL MIL.	CHAMPUS[9]	TOTAL	% UNDER CHAMPUS	APPARENT ADMISSION RATE	EXPECTED ADMISSION RATE [10]
Active Duty Personnel	1.51	1.06	.901	3.47 [1]	2.39	1.30	0.94	4.63 [5]	0	4.63	0	133/1000	—
Dependents of Active Duty Personnel	1.71	.977	1.65	4.34 [2]	1.15	0.82	1.78	3.75 [6]	2.84	6.59	43	152/1000	144/1000
Retired Personnel	0.264	0.243	0.200	0.707 [3]	0.189	0.167	0.171	0.527 [7]	0.190	0.717	26	101/1000	140/1000
Dependents of Retired or Deceased Personnel	0.510	0.379	0.405	1.29 [4]	0.226	0.230	0.292	0.748 [8]	0.650	0.140	46	109/1000	144/1000

Sources of Data:

I. Population:

1. Active Duty Personnel: "Active Duty Military Personnel and their Dependents Worldwide, as of 30 September 1968" Directorate for Statistical Services, OSD, 31 December 1968.
2. Dependents of Active Duty Personnel: Ibid.
3. Retired Personnel: "Retired Personnel of U.S. Armed Forces Residing within CONUS, as of 30 September 1968" Facilities and Requirements Branch, Bureau of Medicine and Surgery, Dept. of the Navy.
4. Dependents of Retired or Deceased Personnel: CHAMPUS Twelfth Annual Report, Chart 4, p. 38 figures for retired subtracted from figures for retired and all dependents of retired or deceased personnel average for CY68.

II. Admissions in Military HC System:

5. Active Duty Personnel:
Army: "Annual Chart Book of the Army Medical Department 1970 (draft)" Chart E-17, Average Daily Admissions in CONUS by Type of Patient, FY69.
Navy: "Admissions in CONUS Navy Hospitals FY68 by Type of Beneficiary" - Facilities and Requirements Branch, Bureau of Medicine and Surgery, Dept. of the Navy.
Air Force: Medical Record Summary Sheets CY1968.
6. Dependents of Active Duty Personnel:
Army: "Health of the Army" Vol. 23, 5-12 and Vol. 24, Nos. 1-4, May 1968 - April 1969, Reference Table "Patient Flow - Admissions in ZI." Admissions for all dependents combined (138,011) were active duty personnel and dependents of retired or deceased personnel according to that observed at Womack Army Hospital, Pervitt Army Hospital, and Waison Army Hospital. In these three hospitals, 85.5% of the total admissions of dependents (18,589) during FY69 were dependents of active duty personnel, the rest were dependents of retired or deceased personnel.
Navy: "Admissions in CONUS Navy Hospitals FY68 by Type of Beneficiary," Ibid.
Air Force: Medical Record Summary Sheets, CY1968.
7. Retired Personnel:
Army: "Health of the Army," as above for retired personnel.
Navy: "Admissions in CONUS Navy Hospitals FY68 by Type of Beneficiary," Ibid.
Air Force: Medical Record Summary Sheets, CY1968.
8. Dependents of Retired or Deceased Personnel:
Army: "Health of the Army," Ibid.
Navy: "Admissions in CONUS Navy Hospitals FY68 by Type of Beneficiary," Ibid.

III. Admissions Under CHAMPUS:

9. OCHAMPUS Phaseback Report 30 November 1968.
Hospital Claims for FY69 by Type of Beneficiary pp. 1-3.

IV. Expected Admission Rate:

Age-Sex breakdown of beneficiaries using hospitalization rates reported by age and sex by Household Interview Survey, National Center for Health Statistics, HEW.

These analyses were performed using the best data available during the study; they might be refined further. But to within the tolerance for error, the analyses of eight of the nine study hospitals and the CONUS-wide analysis including CHAMPUS show that a large fraction of the inpatient demands of the non-military beneficiaries are served outside the BLHC Systems.

Though limited financing may have restricted expansion of the BLHC Systems, the historical workload planning method contributes to deficiencies in estimates. This method's chief fault is allowing a saturated facility to perpetuate itself, even after expansion, as a saturated facility. When demand on the BLHC System grows until it becomes saturated or overloaded, the non-military beneficiaries face long waiting times for outpatient clinic appointments and deferred selective admissions. Those beneficiaries who choose not to wait, seek authorization where required for services at civilian health care systems under the CHAMPUS Program. When the facility expands to meet the projections based on historical workload, the non-military beneficiaries flock back to the BLHC System and saturate it once again.

The historical workload method lacks: 1) an estimate of the demands met in health care systems other than the particular BLHC System under study; and 2) an estimate of future health care demands and resource utilization based on at least partial knowledge of the future.

Planning according to the population to be served, as performed in Great Britain and especially in Sweden, appears to have an advantage over the method of historical workload. It is predictive: a projection of population leads to a projection of the patient care requirements. It is rational: it includes information over and above historical workload. That it is a feasible planning tool for DoD is shown in the remainder of this section.

DEMAND MODEL

The Westinghouse Demand Model is a predictive method for determining patient care requirements for a BLHC System. The rationale of the demand model is shown in Figure 3.1-16. The population served by the BLHC System is classified into five categories: (1) recruits, (2) extended active duty personnel, (3) dependents of active duty personnel, (4) retirees, (5) dependents of retired or deceased personnel.

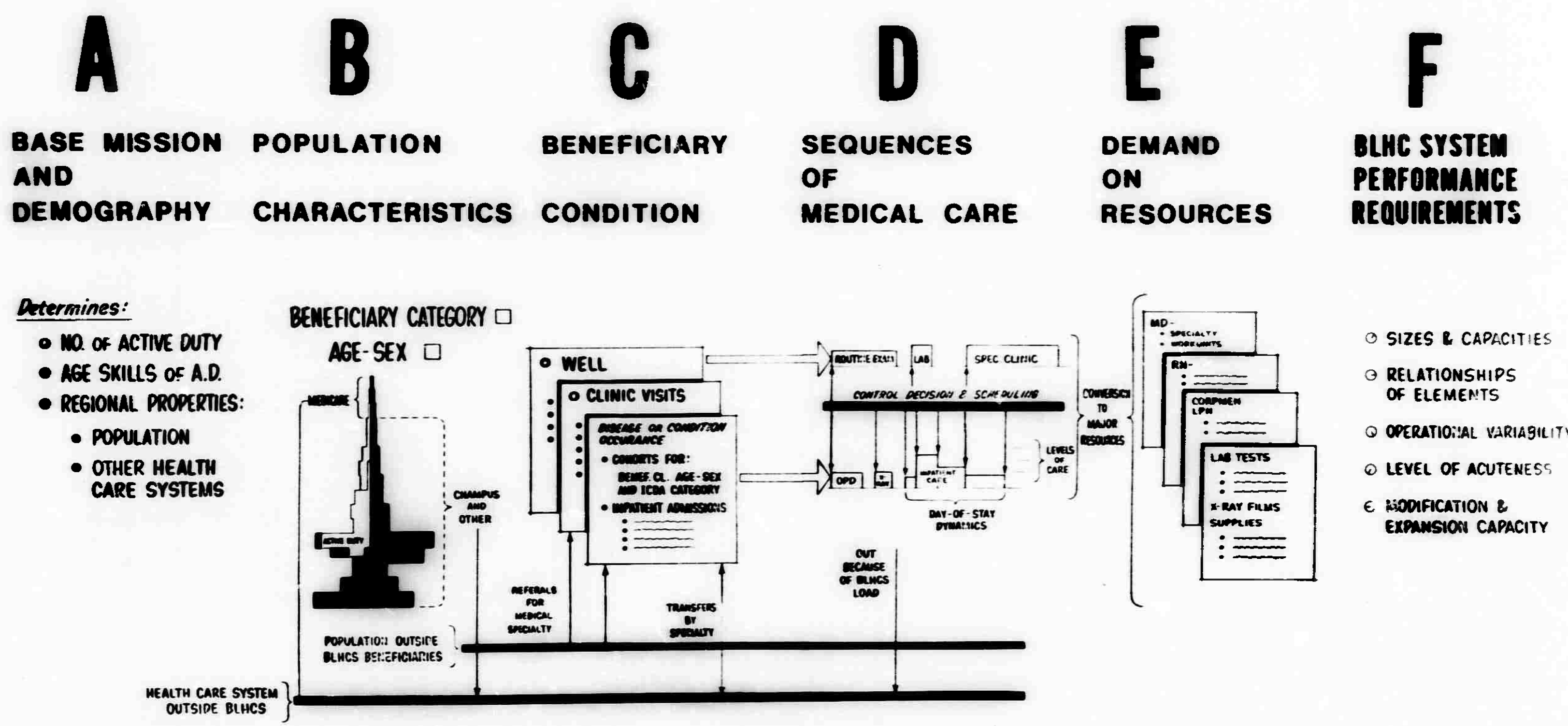


FIGURE 2. THE WESTINGHOUSE DEMAND MODEL

These members of the beneficiary population have conditions, including the well condition, that make demands on the BLHC Systems. The demands take the form of dispensary visits, clinic visits, and inpatient admissions. Admission is a derived demand, i.e., a demand placed on the BLHC System as the result of a decision by a health care professional. In addition, there may be physical examinations or health multitesting.

Episodes of illness, accident, and routine examination bring people into the BLHC System and evoke sequences of medical care, expressed in terms of expenditure of health care resources. This sequence may be, for example, an outpatient visit, hospitalization with its own sequence of care while an inpatient, and two follow-up outpatient visits. These sequences of care depend on the medical practice and technology at the particular BLHC System. At one BLHC System, a patient may stay extra days at the hospital, with the follow-up outpatient visits omitted; at another BLHC System the patient may be discharged earlier onto a light duty status.

Statistical profiles of the sequences of care can be used for purposes of management and control within the facility over a time span of hours to weeks. For predicting and projecting patient care requirements ahead over a period of years, averages and grosser statistics suffice, aggregated from sequences of care. The particular aggregation chosen for the sequences of care depends on the use of statistics and on the availability of data from which to complete them. Since the Demand Model is intended to give information to the systems designers, the output of the Demand Model is as follows:

Outpatient

- Clinic visits/year/specialty clinic
- Dispensary visits/year
- Ancillary usage (X-ray, pharmacy, lab)

Inpatient

- Census in each level of dependency
- Ancillary usage

Data have been collected on sequences of inpatient care. The necessary outpatient data are separate from inpatient records, and are not cross referenced well enough to follow an individual's complete care sequence. Consequently,

the only data collected on outpatient visits were the aggregated statistics.

The structure of the Demand Model is shown in Figure 3.1-17. Each population category is served to a greater or lesser extent by the BLHC System. From this population, so many dispensary visits, outpatient visits, admissions per year are estimated. The distribution of clinic visits among specialty clinics differs for each population category, as does the time, on the average, that each inpatient stays in a level of dependency.

An outpatient visit and an inpatient admission both lead to a certain amount of ancillary usage. Though the data collections from medical records and other sources has yielded the expected ancillary usage per admission by beneficiary type, the existing records were insufficient to determine the ancillary usage to be expected from a particular clinic or by a particular beneficiary type.

The numbers generated during the study have a three-fold purpose:

(1) To show the feasibility of the methodology.

(2) To develop a tool DoD can use.

(3) To find appropriate data to plug into this planning tool.

In order to generate usable numbers, certain assumptions have been made:

(1) Each category of beneficiary has an average age-sex distribution.

(2) The incidence of diseases or conditions (DOC) is the same among the non-military beneficiaries as among the U.S. civilian population, and it does not vary significantly by geographic area of CONUS.

In addition, the patient care requirements for exogenous demands, such as transferred and referred patients, are not considered here. The numbers we have generated are average figures which apply to no particular BLHC System. Even if the aggregated statistics were perfect at one instant of time, changes in medical practice and technology would produce changes in them at some later time. The numbers must be continually updated. By the structure of the Demand Model, the prediction error is linearly proportional to errors in estimates of population or parameters.

These assumptions and restrictions were necessary because of constraints of time and money during the study. In the following sections necessary additional data and methods of collecting them will be pointed out. These extra data will

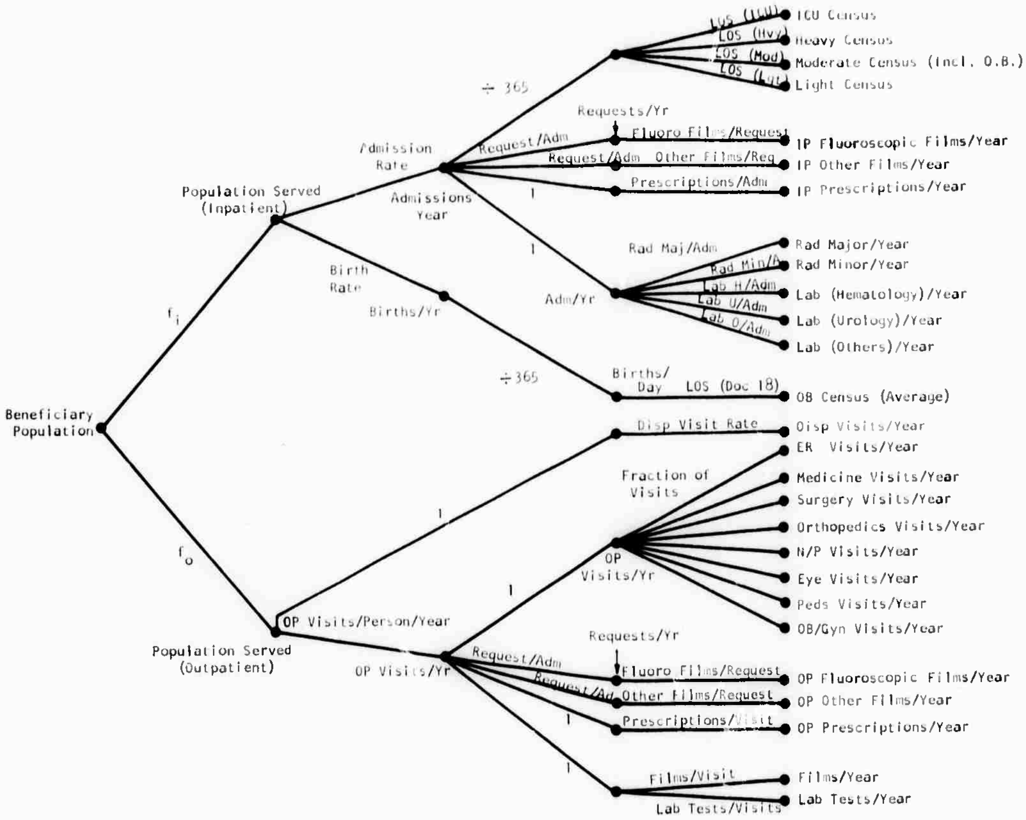


FIGURE 3.1-17 DEMAND MODEL STRUCTURE

allow the assumptions and restrictions to be dropped and the Demand Model applied to the planning of a particular BLHC System.

Predicting Population

Since the starting point for planning using the Demand Model is population, it is necessary to show that DoD can determine the population to be served by a BLHC System, at present and in the future. To keep the cost of planning to an acceptable level, the emphasis here is on more effective utilization of existing data sources within the Department of Defense or within the Federal Government.

The desired data for each category of beneficiary are:

(1) Numbers

(2) Residence or duty station

(3) Age and sex.

Table 3.1-3 is a summary of existing sources of population data and the information each gives. The table indicates:

(1) Military personnel: the numbers, rank, and duty station are known by the base commander and by the office of the chief of the appropriate military service, with projections of strength for five years into the future.

(2) Retired personnel: the residence, age, and sex can be found from machine-readable tapes for each service.

(3) Dependents of active duty personnel: potentially the most informative source of data is the "Record for Emergency," filled out by the sponsor, giving the residence and numbers of dependents. This source of data is believed not to be in machine-readable form, so that only sampling can be conducted.

(4) Dependents of retired or deceased personnel: presumably dependents of retired personnel reside with the sponsor. Dependents of deceased personnel can be located through the office of the paymaster of the appropriate service for these dependents.

Additional sources of data could include the Census Bureau, Social Security Administration, Internal Revenue Service, Retired Sections and Casualty Sections in each service to locate dependents of sponsors serving overseas.

TABLE 3.1-3

POPULATION DATA SOURCES

Beneficiary Category	Source of Data	Information	Comments
Military Personnel	• Base commander and headquarters of the appropriate service	Duty station, local address, rank	
Dependents of Active Duty Personnel	• Record for emergency form (filled out by sponsor)	No. of dependents, address, ages of children	Not machine readable
	• Census Bureau (cross-referenced and through occupation of head of household)	Address, age/sex of household members	Only decennially surveyed
	• Housing surveys near base	Address, number of members of household	periodically conducted
	• Internal Revenue Service (cross-referenced through Social Security Number of sponsor)	Address, number of dependents	
Retired Personnel, Dependents of Retired or Deceased Personnel	• OSD - Manpower of Reserve Affairs	Address, number of checks sent (dependents)	
	• BUPERS (PAMICONUS 1080-1135-E-SA)	Retirees and dependents by zip code	Navy only
	• Navy Finance Center, Quarterly Zip Code Report	Retirees and dependents by zip code	Navy only
	• Army Retired Section	Address and age of retirees	Army only; machine-readable tapes
	• Air Force Retired Personnel Section	Retirees - address by zip code	

Estimating Health Care Demand

Required are BLHCS dispensary visits, outpatient visits, and inpatient admissions expected over a period of time assuming all those authorized for care were to apply to the BLHC System.

Military personnel receive nearly all their short-term health care within the BLHC System. Their numbers are known and their incidence rate of diseases or conditions can be effectively computed. Admission and length of stay statistics for enlisted recruits can be computed separately from other military personnel in the Navy and Air Force through their machine-readable medical record summaries. Outpatient and dispensary records do not distinguish recruits from other military personnel. Estimation of the demands for these two categories can be separated in a gross fashion by regression analysis, as has been seen, or by sampling records at the individual base. These statistics are presented in the first two columns of Table 3.1-4.

The non-military beneficiaries, on the other hand, receive some of their care in health care systems other than the BLHC System. To estimate potential

TABLE 3.1-4

POTENTIAL PATIENT DEMAND

	Dispensary Visits/Year	Outpatient Visits/Year	Admissions/ Year
Recruits	14	5.2[1]	.885[1]
Active Duty Personnel	3.8	5.2[1]	.170[1]
Dependents of Active Duty	-	3.9[3]	.144[2]
Retired Personnel	-	4.7[3]	.140[2]
Dependents of Retired or Deceased Personnel	-	3.7[3]	.144[2]

1. 8 Study BLHC Systems
2. "Discharges from Short-Term Hospitals", Household Interview Survey, Series 10, National Center for Health Statistics, Public Health Service, Dept. H.E.W., adjusted for age-sex distribution.
3. Statistical Report, 1965, Health Insurance Plan of New York, adjusted for age-sex distribution.
4. Apparent admission rate in CONUS, CY68.

demand from the non-military beneficiaries, comparison was made with civilian health care systems. Statistics on discharges from short-term civilian hospitals (Household Interview Survey, DHEW) were used to estimate inpatient admissions. These statistics, listed by age and sex, were used with the age-sex breakdowns of the non-military beneficiaries to arrive at the numbers shown in column three of Table 3.1-4. The apparent admission rates of active duty dependents, derived from the sum of admissions under CHAMPUS and in the military health care system is five percent more than that predicted through statistics on the U.S. civilian population. The same comparison for retirees and dependents of retired or deceased personnel shows that the apparent admission rates are lower. This is expected since these beneficiaries have options for health care other than CHAMPUS and BLHC Systems.

Potential outpatient visits of the non-military beneficiaries must be inferred from civilian statistics alone, since the deductibles and coinsurance of CHAMPUS show outpatient visits less than their actual number. The statistics used to predict potential outpatient visits should be taken from a health care system where: (1) the beneficiaries are not restrained from seeking health care by either financial penalties or long delays in service, (2) all demands of beneficiaries are served in the health care system, and (3) the practice of medicine is similar to that in BLHC System. In general, U.S. comprehensive prepaid health care plans most closely satisfy these criteria.

The best continuing set of statistics is published by the Health Insurance Plan of Greater New York (H.I.P.), which provides comprehensive health care services for its enrollees through contracts with 31 autonomous groups of physicians. The enrollment in the plan in 1968 was 783,829. To derive potential outpatient visits, the age-sex breakdowns by beneficiary category were used with H.I.P. statistics on outpatient visits by age for 1965 (the most recent year for which reports from H.I.P. were available). The results are shown in column two of Table 3.1-4.

The distribution of clinic visits is needed, in addition to their total number. To allow comparison of BLHC System and civilian statistics, subspecialties were grouped under one of eight major clinic specialties. The eight major clinics and their subspecialty clinics are shown in Table 3.1-5. As a rule, a BLHC System does not report the number of visits to each clinic by beneficiary

TABLE 3.1-5 - DEFINITION OF SPECIALTY CLINICS

	ARMY	NAVY	AIR FORCE
1. Orthopedic	Orthopedic	Orthopedic	Orthopedic
2. Pediatric	Pediatric	Pediatric	Pediatric
3. Obstetrics	Obstetrics Gynecology	Obstetrical Gynecology	Obstetrics Gynecology
4. Ophthalmology	Eye	Ophthalmology	Ophthalmology Optometry
5. Neuropsychiatry	Neurology Neuropsychiatry EEG	Psychiatry Psychology	Psychiatric Neurology Psychology Psy. Social Work
6. Surgery	Surgical ENT G.U.	General Surgery Neurosurgical Plastic Surgery Thoracic Surgery Otorhinolaryngo-logy Urology	Otolaryngology Podiatry Neurosurgery Surgery Plastic Surgery Thoracic Surgery Urology
7. Medical	Medical Allergy Dermatology Venereal Dis. General Out-patient Clinic Visits	Allergy Cardiology Chest Disease Dermatology Endocrinology Gastroenterology General Medicine Proctology	Allergy Cardiology Dermatology Pulmonary Gastroenterology Endocrinology Rheumatology Renal Internal Medicine General Practice
8. Emergency Room Visits		Emergency Room	Emergency Room

Clinics or services not included in the eight basic areas but considered an outpatient visit by their branch of service:

(Army)	(Navy)	(Air Force)
Occupational Therapy Physical Therapy	Anesthesiology Hematology Occupational Therapy Physical Therapy	Hematology

NOTE: Workload procedures, such as x-rays and lab. orders, are not included.

type. Such information was, however, collected at Walson Army Hospital and Malcolm Grow Air Force Hospital. For comparison, H.I.P. statistics for physician visits by specialty in 1965, reported by age, were used along with the age-sex breakdown of beneficiaries.

The percentage distribution of outpatient visits by non-military beneficiaries is shown in Table 3.1-6; the details are in Appendix 3.1-5. Also shown is the distribution of active duty personnel. The best fit is at Malcolm Grow Air Force Hospital, where the raw data was most detailed.

General medicine and emergency room visits have been shown separately for the study hospitals. The sum of these percentages approximates the percentage shown for H.I.P. general medicine. At some study hospitals, the emergency room is used as a walk-in clinic by the non-military beneficiaries who do not wish to wait for an appointment. The percentage of emergency room visits for diseases or conditions that are life-or-limb threatening has been estimated at less than 10 percent of emergency room visits by physicians at the study hospitals. In the Demand Model, the fraction of general medicine visits seen in the Emergency Room at Malcolm Grow has been used as the number of patients to be seen at a walk-in clinic.

The figures on potential demand have been inferred from a variety of sources and do not apply to any particular BLHC System. They are, however, the best possible estimates given the time and financial limitations of the study.

Since statistics taken from overcrowded facilities will lead to underestimation of demand, the demand on a BLHC System has been estimated with reference to civilian health care statistics. Such estimation, however, is no substitute for actual demand statistics on the population served by a BLHC System. At present the office of CHAMPUS, through its subcontractors, does not report claims by geographic area smaller than a state. These records if sampled to estimate CHAMPUS claims by county or by zip code and by beneficiary type, can provide an estimate of the demands served outside a particular BLHC System.

If planning for a regional and/or specialty center is also required, patient care requirements for the population at or around such a center, are predicted. Then the exogenous demands, such as transfers in, are estimated and the resulting patient requirements added. These same demands would, of course, be subtracted from the demands at the referring hospitals.

The health care planner may be bound by policies made at a higher level.

TABLE 3.1-6 - PERCENTAGE DISTRIBUTION OF VISITS TO OUTPATIENT SPECIALTY CLINICS BY CATEGORY OF BENEFICIARY[1]

		ORTHO	OB/GYN	PEDS	EYE	N/P	SURG	MED	ER
AD	HIP	—	—	—	—	—	—	—	—
	AND	6	0.8	0	4	10	16	43	20
	BFT	44	*	*	12	*	44	*	*
	DIX	15	0.5	0	6	*	19	20	40
Dep. AD	HIP	4	6	33	3	—	7	47	—
	AND	3	14	29	1	2	7	20	23
	BFT	*	*	*	*	*	*	*	—
	DIX	6	*	75	*	*	*	*	21
Ret.	HIP	4	0	0	5	—	14	75	—
	AND	2	0	0	3	5	11	39	39
	BFT	9	*	*	*	*	91	*	*
	DIX	4	3	0	4	*	14	68	6
Dep. Ret.	HIP	4	6	18	3	—	10	59	—
	AND	5	6	8	1	2	7	37	34
	BFT	*	*	*	*	*	*	*	*
	DIX	*	*	*	*	*	*	*	*

* Figures broken down by beneficary were not available from clinic noted.

1 Each entry in the table is the percentage of visits by the category of beneficiary to the specialty clinic, according to the source of data.

AND = Malcolm Grow AFB, BFT = Beaufort N.H., and DIX = Walson A.H.

The fraction of each beneficiary category to be served may be restricted to something less than unity, and it is outside the scope of this contract to determine whether all the demands of the non-military beneficiaries should be served in the BLHC System. Such parameters must be prescribed by DoD.

Predicting Patient Care Requirements

Knowing the number of dispensary visits, outpatient visits, and inpatient admissions gives some information to the system designer, but not enough. Patient care requirements resulting from this demand must be predicted. They may be derived from statistics on patients treated in the facility itself or in similar facilities, updated to account for changes in medical technology or practice. These additional requirements are bed occupancy by level of dependency and ancillary usage. The average level of dependency gives information crucial to determining staffing and support requirements for inpatient care. Ancillary usage is split into the components due to inpatients and outpatients; these statistics lay the foundation for sub-system design.

Since the activities under ward management absorb a large fraction of the operating costs (from 15 to 30%) of the study BLHC Systems, the sequences of care for inpatients are studied in detail. In addition to providing raw data for aggregation as hard numbers, these sequences give qualitative information to the system designer.

Patient Classification

At Beaufort and Jacksonville Naval Hospitals data on level of dependency and ancillary usage by day of stay were collected from medical records selected at random. A summary of the data collection is in the Data Inventory volume. The computerized sorting and tabulating system is described in Appendix 3.1-6; the detailed reports are contained in the microfiched computer printouts.

To show that these random samples of medical records accurately reflect the patient mix at the two hospitals, the samples can be compared to statistics on overall admissions and length of stay. In the data collection, days absent from the hospital, such as on leave, were noted. They are not counted in the statistical reporting. A patient was considered to be in the hospital a full day on the day of admission and discharge.

The sample at Beaufort Naval Hospital was 5 percent of the total admissions during FY68. The population and admissions for each category of beneficiaries

are shown in Table 3.1-7, along with the sample composition. The percentages of admissions in the sample correspond remarkably well to the percentages of actual admissions. The sample average length of stay (LOS) for military personnel, calculated at 29.9 days compares favorably with the 28 days reported by the registrar. The average LOS for all patients combined in the sample is 18.6 days as compared to the 18 computed from data pack information. These checks show that the sample does in fact accurately represent the patient mix at Beaufort.

The sample at Jacksonville Naval Hospital was 4.3 percent of the admissions in FY68. The sample and actual composition of admissions, as shown in Table 3.1-8, shows a greater variation than does the Beaufort sample, but within the allowable error of the sample size. The lengths of stay by beneficiary category for the sample and actual (as determined from data collection at Jacksonville) show an acceptable variation.

At each hospital data from the medical record was coded by level of dependency. At Beaufort Naval Hospital physicians presently classify patients other than infants into five classes: Class V (heavy care), Classes III and IV (moderate care), and Classes I and II (light care). Jacksonville Naval Hospital does not have a patient classification system. The criteria used at Beaufort Naval Hospital as determined by physician interview and by comparison of the medical records with the classification were modified and extended for use on all patients at Beaufort and were carried over to the study at Jacksonville. The methodology for classifying patients is:

(1) Intensive or ICU care was noted whenever a patient was transferred into and from ICU or CCU, or in the case of newborns, isolette or croupette.

(2) Heavy care was noted whenever any of the following conditions were satisfied:
   - Nursing notes indicated the patient was bedridden;
   - Nursing notes indicated respiratory assistance or IV's;
   - The patient was admitted bedridden and not yet been noted as walking.

(3) Moderate care was noted whenever any of the nursing notes indicated the patient had begun to walk and/or had bathroom privileges, but had not yet satisfied the conditions of light care. All newborns were considered to be receiving moderate care unless nursing notes indicated otherwise.

TABLE 3.1-7

BEAUFORT NAVAL HOSPITAL SAMPLE COMPOSITION

BENEFICIARY CATEGORY	AVERAGE POPULATION SERVED FY68	INPATIENT ADMISSIONS FY68	FRACTION OF ADMISSIONS	NUMBER IN SAMPLE	FRACTION OF ADMISSIONS IN SAMPLE
Uniformed Services or Active Duty Military Total	16,916	2,146	.522	102	.500
Dependents of Active Duty	12,683	1,685	.410	92	.451
Retired Personnel	500	122	.030	7	.034
Dependents of Retired and/or Deceased	750	139	.034	3	.015
Other Authorized Treatment	1,176	18	.004	0	0
Total	32,025	4,110	1.000	204	1.000

TABLE 3.1-8

JACKSONVILLE NAVAL HOSPITAL SAMPLE COMPOSITION

BENEFICIARY CATEGORY	AVERAGE POPULATION SERVED FY68	INPATIENT ADMISSIONS FY68	FRACTION OF ADMISSIONS	NUMBER IN SAMPLE	FRACTION OF ADMISSIONS IN SAMPLE
Uniformed Services or Active Duty Military Total	35,241	3,072	0.346	114	0.302
Dependents of Active Duty	49,337	3,567	0.402	207	0.549
Retired Personnel	13,074	780	0.088	27	0.072
Dependents of Retired and/or Deceased	28,845	1,122	0.127	18	0.048
Other Authorized Treatment	2,682	332	0.037	11	0.029
Total	129,179	8,873	1.000	377	1.000

(4) Light care was recorded whenever nursing notes indicated the patient had been sent on convalescent leave, assigned a task within the hospital or transferred to the old hospital.

Table 3.1-9 summarizes the length of stay and average level of dependency at Beaufort Naval Hospital. Infants in the nursery are shown separately. Though the length of stay and level of dependency vary with disease or condition and age, the difference between beneficiary categories is most important. The length of stay for Parris Island recruits was 36.6 days of which, on the average, 21 days were spent in light care. Other active duty personnel showed a similarly long stay in light care. On the other hand, dependents had short overall lengths of stay and spent a small fraction of their stays in light care. The same information for Jacksonville Naval Hospital, shown in Table 3.1-10, shows the same distinction between active duty personnel and non-military beneficiaries (there are no recruits at Jacksonville).

Since the methodologies for collecting and tabulating the data were the same for both hospitals, the analyses of level of dependency can be combined. The average LOS in a level of dependency is approximately equal to the total length of stay, times the fraction of the stay, in that level of dependency. The census in each level of dependency is equal to the average daily admissions times the following figures:

CENSUS IN LEVEL OF CARE BY AVERAGE DAILY ADMISSIONS

	Recr	A Duty	Dep Ad	Retir	Dep Rt
ICU	0.366	0.295	0.062	0.354	0.243
HEAVY	1.470	0.884	0.742	5.840	1.380
MODCAR	13.600	8.540	5.190	7.620	6.400
LIGHTC	21.200	19.700	0.185	3.900	0.081

Because of the long length of stay of military personnel in light care, where the patient is fully ambulatory, their requirements are studied in more detail. In all these analyses, days not spent in the hospital are not counted. The average length of stay for military personnel in levels of dependency other than light care was approximately 9.5 days. The average and median length of uninterrupted light care immediately preceding discharge was calculated for Parris Island recruits, and for other military personnel, and adult dependents at the two hospitals:

TABLE 3.1-9

SUMMARY OF LENGTH OF STAY AND LEVEL OF CARE FROM BEAUFORT NAVAL HOSPITAL INPATIENT MEDICAL RECORD SURVEY

			AVERAGE PERCENT IN EACH LEVEL OF CARE				
BENEFICIARY CATEGORY	NUMBER IN SAMPLE	AVERAGE LENGTH OF STAY	ICU	HEAVY CARE	MODERATE CARE	LIGHT CARE	NURSERY
Active Duty							
Recruits	52	36.6	1	4	37	58	0
Vietnam Related	9	30.0	0	6	9	86	0
All others	41	21.4	1	9	41	50	0
Combined	102	29.9					
Dependends of Active Duty	92	6.4	0	16	62	5	17
Retired	7	16.9	0	2	53	45	0
Dependents of Retired	3	9.0	4	67	26	4	0
Total	204	18.6	1	8	40	49	3

Note: The percentages in each level of care were displayed only to the nearest percent. Because of computer rounding, some totals may not sum to exactly 100.

TABLE 3.1-10

SUMMARY OF LENGTH OF STAY AND LEVEL OF CARE FROM JACKSONVILLE, N.H. INPATIENT MEDICAL RECORD SURVEY

BENEFICIARY CATEGORY	NUMBER IN SAMPLE	AVERAGE LENGTH OF STAY	AVERAGE PERCENT IN EACH LEVEL OF CARE				
			ICU	HEAVY CARE	MODERATE CARE	LIGHT CARE	NURSERY
Active Duty							
Vietnam Related	1	145.	0	0	9	91	0
All others	113	32.4	0	2	26	72	0
Dependents							
Active Duty	207	6.1	1	10	67	3	20
Retired	27	17.9	3	41	40	16	0
Dependents of Retired	18	7.9	3	8	89	1	0
Other	11	13.1	31	8	56	6	0
Totai	377	15.5	2	7	38	49	4

Note: The percentages in each level of care were displayed only to the nearest percent. Because of computer rounding some totals may not sum to exactly 100.

	Mean	Median
Parris Island Recruits, no surgery	16	10
surgery	22	15
All other military, no surgery	5	1
surgery	10	7
Adult dependents, no surgery	1	0
surgery	1	0

From the detailed computer reports the major disease or condition categories in which the length of stay in light care was longest are shown in Table 3.1-11. Based on the above two tables, some observations are:

(1) Patients who underwent surgery, especially recruits, spend more time convalescing in the hospital than non-surgical patients.

(2) Adult dependents spend much less time recuperating in the hospital than military beneficiaries.

(3) Orthopedic and neuropsychiatric patients and patients hospitalized for external causes and injuries stay the longest in light care.

The disparity of the length of stay in light care between the military and non-military beneficiaries appears to be due to the following causes:

(1) Military patients do not have as much accessibility to family care at home as the non-military beneficiaries. This problem is particularly acute in the Navy, because their enlisted men marry less frequently than those in the other two services.

(2) Some medical treatments require extended patient stays, for example, observation for neuropsychiatric disorders and orthopedic therapy. More military than non-military beneficiaries are treated for these conditions in the BLHCS.

(3) The requirement that a medical board determine the military patients' physical and mental fitness for full duty creates opportunities for continued stay while awaiting medical or disposition board action.

The average LOS of Air Force military personnel admitted in CONUS in 1968 was 12.5 days.* In large part this is a reflection of the fact that home care is more often available. They also have a lower percentage of orthopedic cases in their patient mix than in Beaufort and Jacksonville Naval Hospitals.

*Source: Medical Record Summary Sheets

TABLE 3.1-11

LIGHT CARE BY DISEASE OR CONDITION

	RECRUITS			OTHER ACTIVE DUTY		
Diseases or Conditions (DOC)	Admissions	Avg. Light Care Days per Admission	% of Time in Light Care	Admissions	Avg. Light Care Days per Admission	% of Time in Light Care
Diseases or Conditions of the bone	2	40	0.71	11	32	0.88
External Causes and Injuries	23	25	0.66	33	38	0.65
Mental and Personality Conditions	0	0	0	12	26	0.98

Womack and Walson Army Hospitals often release patients from the hospital into a Medical Holding Company, which may not reduce the length of time absent from duty but does free beds. The medical necessity for light care and opportunities for more efficient discharge procedures have not been studied in detail here. These results do indicate, however, that these two areas should be studied further by the services.

Sequence of Care

The sequence of inpatient care yields information on the patient care requirements over a span of days to weeks. This short-term information, if continuously updated, provides a foundation for allocating staff to the different wards and ancillary functions. Retrospective averages provide information for the system designer. For military personnel, Figures 3.1-18 to 3.1-21 exhibit the total number of patients and levels of dependency for the day of admission and selected days thereafter. The military personnel show a steady transition from moderate care to light care after day two. For those patients who underwent surgery the data suggest that the day of admission is devoted to pre-operative tests. The non-military beneficiaries, not shown here, show a monotonic transition from heavy to moderate care or remain in moderate care for their entire stay. Laboratory and radiology requirements peak on the day of admission, remain substantial on days two and three, and decline to low levels on succeeding days. The declining levels of dependency during the stay show that:

(1) patient nursing care requirements can be satisfied either by retaining fixed ward staffing and transferring the patient to another ward or by adjusting the staff levels in each ward to suit the care requirements of the patients.

(2) the heavy ancillary usage on the day of admission, coupled with the high level of dependency, requires that the ancillary facilities be fully accessible to inpatients.

Ancillary Usage

Ancillary usage is defined here as laboratory usage, radiology room usage, and pharmacy prescriptions. Since traffic patterns to and from these locations depend on whether the patient is an inpatient or outpatient, the sources of ancillary usage have been split between these types of patients.

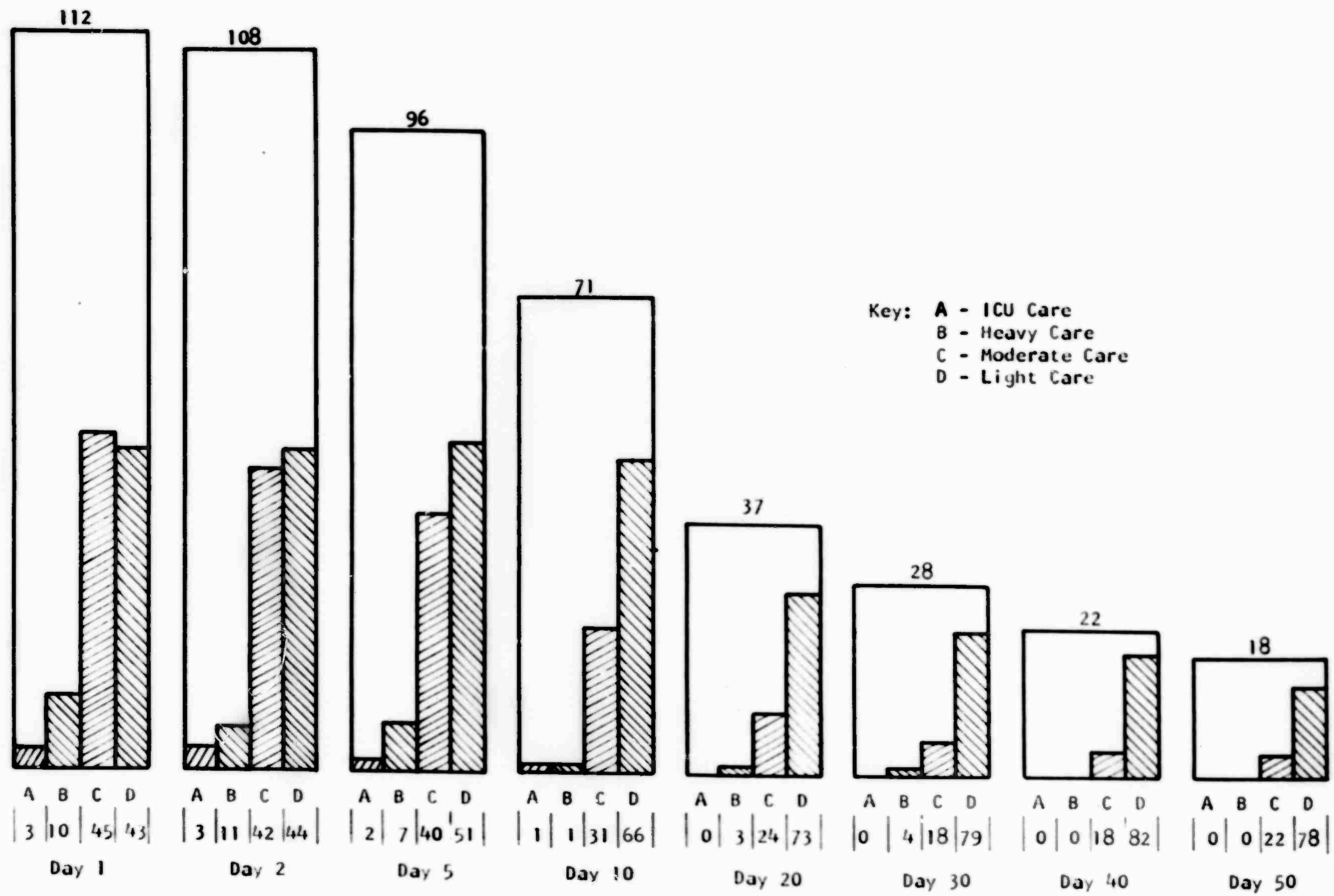


Fig. 3.1-18-Levels of care vs time after admission (non-surgical military excluding recruits and Viet Nam related)

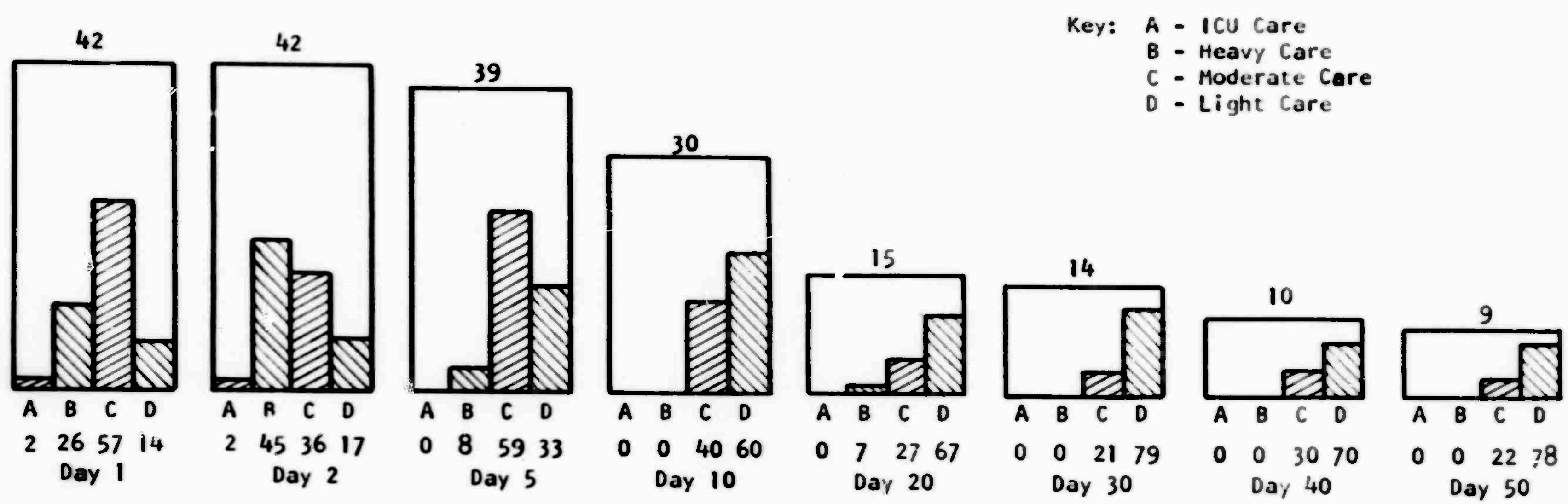


Fig. 3.1-19 —Levels of care vs time after admission (surgical) military (excluding recruits and Viet Nam related)

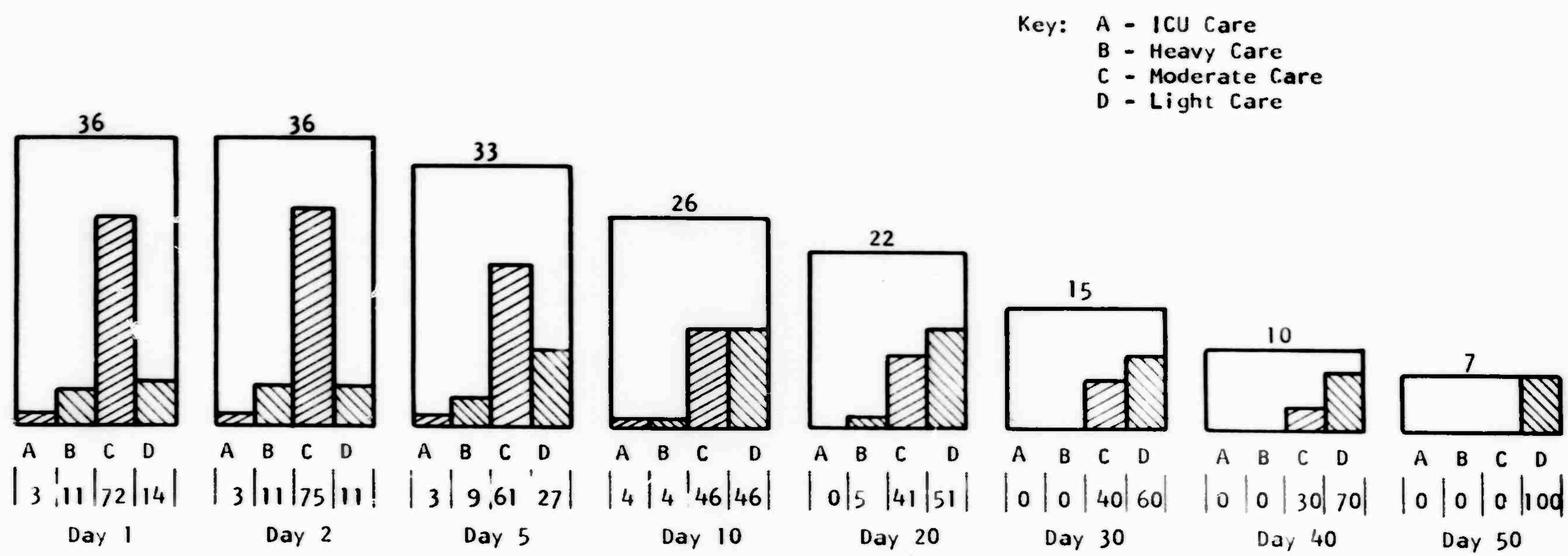


Fig. 3.1-20—Levels of care vs time after admission (non-surgical) military (recruits)

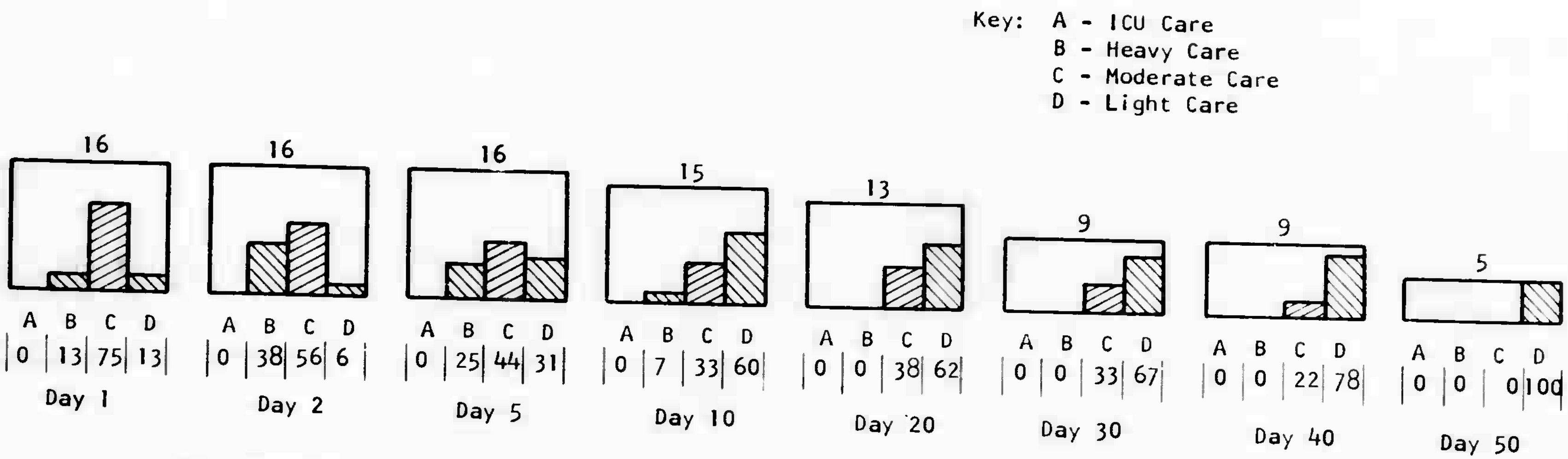


Fig. 3.1-21—Levels of care vs time after admission (surgical) military (recruits)

The inpatient medical records collected at Beaufort and Jacksonville show that most ancillary usage occurs on the first and second days of treatment. Though these records allow a study of ancillary usage by DOC,* beneficiary type by day of stay, age, and sex, the number of records in the sample does not justify such a detailed breakdown. The level of aggregation chosen here is, therefore, limited to ancillary usage by beneficiary type per admission. The Beaufort/Jacksonville data on ancillary usage is in Table 3.1-12. More detailed breakdowns are contained in microfiched medical statistical reports Nos. 3 and 4.

Table 3.1-13 indicates the number of X-rays, lab tests, and prescriptions resulting from a request for ancillary services. Lab chits from Walson Army Hospital were analyzed to determine lab tests per request. The number of X-ray films resulting from a request as well as the number of prescriptions per admission were determined via interviews of qualified personnel at the study hospitals. To distinguish the number of fluoroscopic X-ray films from the number of other X-ray films, expert consultants were queried both on the requests per admission and on the number of films per request. For out-patient visits, existing records did not allow the data collection to determine ancillary usage either by beneficiary type or by clinic. Requests per visit and films per request for fluoroscopic and other films were elicited from consultants. Figures for prescriptions and lab tests per visit were taken from management data prepared by HQ USAF (AFMSHC) for FY67, taken from management reports RCS:IR (AF)M-219 and -220.

These ancillary usage data have been assembled to demonstrate that the numbers required for the Demand Model can be found. These numbers, however, should be refined before the Demand Model is applied to an actual BLHC System.

Estimating Bed Needs

The required number of beds in a facility depends both on the average census and on the fluctuations in that census. If the fluctuations are wide, then it is necessary to have a greater number of beds unoccupied on the average to ensure the availability of facilities when demand is high.

Currently, hospitals have been designed using a desired bed occupancy rate of 80 percent. With a probability approach, the chances of the bed occupancy reaching the number of active operating beds (authorized) is set at a suitably

*Disease or Condition

TABLE 3.1-12

INPATIENT ANCILLARY REQUESTS PER ADMISSION[1]

	Recruits	Active Duty	Dep. A. D.	Retired	Dep. Retired
Hematology[2]	1.4	1.4	1.1	4.4	2.5
Urology[3]	1.2	1.2	1.2	2.1	1.2
Other	1.3	1.3	0.9	4.2	2.7
Radiology-Major[4]	0.4	0.4	0.1	0.7	0.1
Radiology-Minor[5]	0.6	0.4	0.4	0.6	0.4

1. Combined Beaufort and Jacksonville Naval Hospital Medical Records
2. Any test or combination of tests noted on Standard From 514-B, including:
   - a. White Blood Cells
   - b. Differential Count
   - c. Platelets
   - d. Sedimentation Rate
   - e. Red Blood Cells
   - f. Hematocrit
   - g. Hemoglobin
   - h. Bleeding Time
   - i. Coagulation Time
3. Any test noted on Standard Form 514-A, including:
   - a. Reaction
   - b. Specific Gravity
   - c. Albumin
   - d. Sugar
   - e. Acetone
   - f. Bile
4. Standard chest film(s).
5. Any other radiological procedure.

TABLE 3.1-13

ANCILLARY USAGE

	Requests per Visit on Admission	Films/Tests per Request
INPATIENTS		
Fluoroscopic	0.1[1]	10[1]
Other X-ray	0.66[1]	3.5[1]
Lab Tests	4.5[2]	3[3]
Prescriptions	8.0[1]	-
OUTPATIENTS		
Fluoroscopic	0.005[1]	10[1]
Other X-ray	0.13[1]	3.5[1]
Lab Tests	-	0.6[4]
Prescriptions	0.9[1]	-

1. Project Consultants
2. Beaufort and Jacksonville Medical Records
3. Lab chits from Walson A.H.
4. Tests/Visit USAF Medical Management Data Tables, FY67.

low figure. The method is to find the statistics of bed occupancy and to determine the desired probability that occupied beds will not exceed the operating beds. From the statistics come the corresponding number of operating beds.

Then statements are made about the fluctuations in demand for beds under the assumption that requests for admissions are independent of each other and occur at some average rate λ admissions/day (Poisson distribution). Though it is possible to distinguish between elective and emergency admissions for purposes of scheduling,[1] fluctuations in census are studied under the assumption that admissions are either accepted or referred elsewhere.

The overall model for studying fluctuations in census is that of a stream of patients for whom admission is requested arriving independently of each other at some average rate. The hospital is modeled as having an infinite number of beds and the statistics of the occupied beds are sought. Though no hospital has an infinite number of beds, the number of operating beds is usually sufficiently greater than the average census, so that the tail of the distribution of occupied beds can be conveniently approximated with this assumption.

The next important statistical quantity is the length of stay within the hospital. The length of stay is a random quantity, which can be statistically characterized. A convenient simplifying assumption is that the distribution of length of stay is a negative exponential, $\mu e^{-\mu t}$. Using this assumption the number of occupied beds can be analyzed by the method of birth-and-death processes in queueing theory to yield [2,3] the distribution of the number of occupied beds in the steady state by a Poisson distribution Probability (n beds occupied) = $e^{-m} \frac{m^n}{n!}$ when m = λ/μ the average census. Such a result has been widely used previously[4] as a basis for determining the number of hospital beds for a facility.

What is not widely known is that the assumption of negative exponential service time can be relaxed if the time axis is discretized. Consider time

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[1]Young, J.P. "Stabilization of Inpatient Bed Occupancy Through Control of Admissions," Hospitals, J.A.H.A., Volume 39, No. 19 (1965).

[2]Feller, W. An Introduction to Probability Theory and Its Applications, 3rd ed., Vol. I, John Wiley & Sons, New York, 1968, pp. 460-461.

[3]Parzer, E. Stochastic Processes, Holden-Day Co., New York, 1962.

[4]Rosenthal, G.D. "The Demand for General Hospital Facilities," Hospital Monograph Series No. 14, American Hospital Association, Chicago, 1964.

measured by non-zero intervals, for example, by days. Patients are assumed to be in the hospital during the entire interval. As before, the number of requests for admission within a time period is considered to be Poisson - distributed with average number λ/period. The distribution of length of stay is assumed to be zero after some finite number n of time periods, but may be otherwise arbitrary. Then by using moment-generating techniques it can be shown[5] that the distribution of the number of patients occupying beds during a time interval is Poisson distributed with average length of stay m given by

$$m = \lambda \sum_{i=0}^{n} (1 - F_s(i))$$

where F_s (i) is the probability of staying less than or equal to i time periods (cumulative distribution function). This result shows that the Poisson distribution for census has more generality than previously realized, and in particular may be used for a nearly arbitrary distribution of length of stay.

It is significant to compare the number of beds computed by this method with the 80% occupancy rate rule. The variance of the Poisson distribution is such that the higher the average census, the less, relatively speaking, the fluctuations in census. Figure 3.1-22 plots the number of operating beds as a function of average census for the 80% occupancy and for probability 0.99 (99% confidence level) and .999 that the demand for beds does not exceed the operating beds. From this graph it can be seen that for an average census greater than 100, the 80% occupancy rate leads to an oversized facility. Conversely for fewer than 100 beds, the 80% rule results in an undersized facility. The cross-over number will vary depending on the confidence level chosen; for a 99.9% confidence level it is an average census of 150.

The result is applied in determining the number of operating beds for each level of dependency. The designer sets the highest confidence level for beds in the highest level of dependency, for example the ICU, with successively lower probabilities for the lower care levels.[6]

In existing BLHC Systems, the census averaged by month, shows a yearly cycle due to the influx of admissions for upper respiratory infections (URI)

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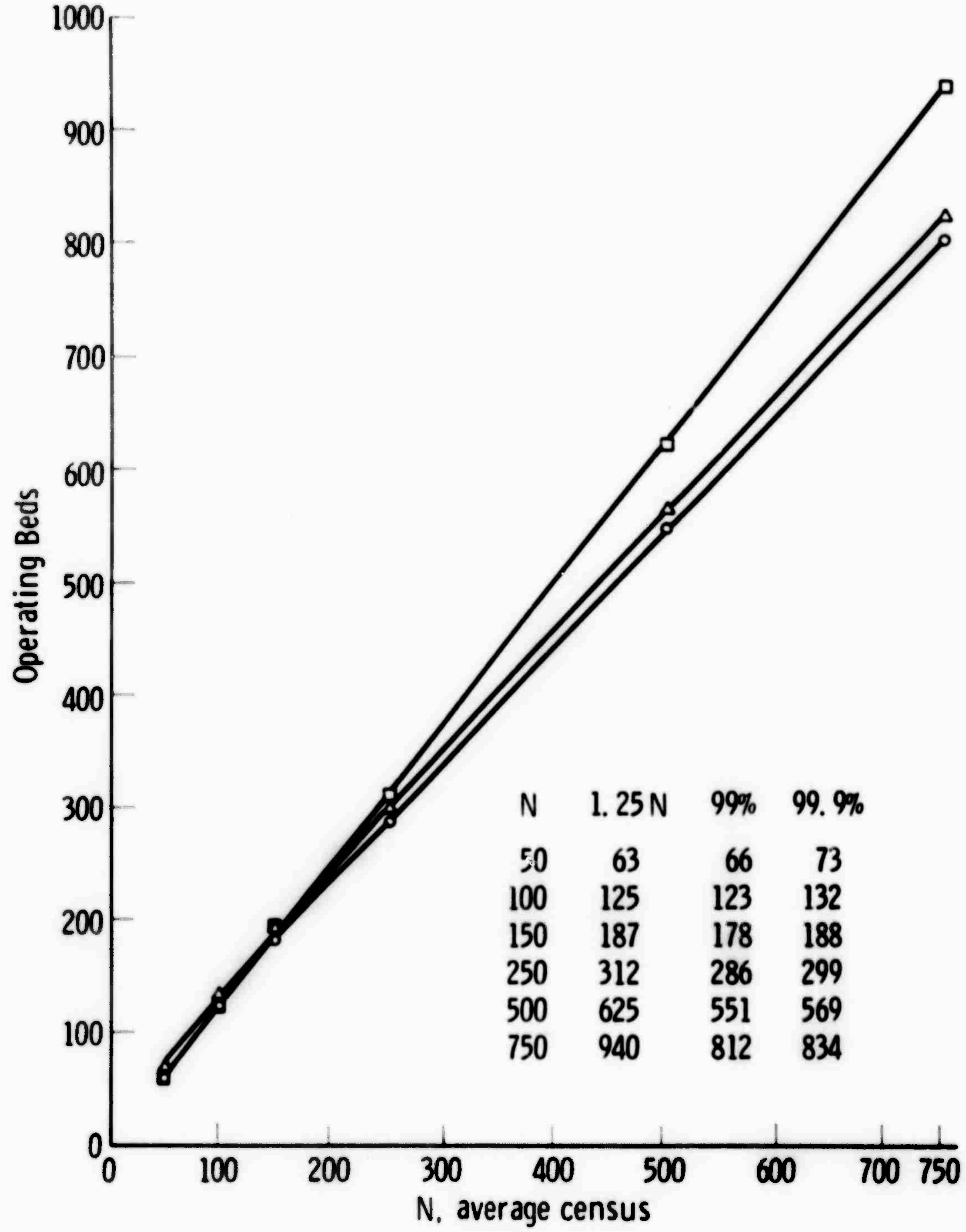
[5]Avi-Itzhak, B., Benn, B.A., and Powell, B.A. "Car Pool Systems in Railroad Transportation: Mathematical Models," Management Science, Vol. 13 No. 9, May 1967, pp. 694-711.

[6]Flagle, C.D. et. al. "The Progressive Patient Care Hospital," U.S. Public Health Service, Dept. Health, Education, and Welfare, Pub. No. 930-C-2 Washington, D.C., 1963.



N	1.25N	99%	99.9%
50	63	66	73
100	125	123	132
150	187	178	188
250	312	286	299
500	625	551	569
750	940	812	834

Fig. 3.1-22—Operating beds vs average census N for 80% occupancy (□), 99% confidence level (○) and 99.9% confidence level (△)

from January through March. At Walson Army Hospital, the yearly variation in URI admissions is three times greater than the variation for all other admissions. A similar disparity in yearly variation is true for the Air Force (Biostatistical Report, 1967). Since URI patients typically receive only light care, the comparison shows that this probability method may be applied straightforwardly to the areas designated for the higher levels of dependency. The areas devoted to light care must be sized with the yearly variation in URI admissions included.

CONCLUSIONS

The planning problem addressed in this chapter is that of determining the patient care requirements at a BLHC System. Two alternatives have been assessed on the basis of prediction, rationality, and feasibility.

The method of historical workload allows saturated health care facilities to perpetuate themselves as such. The comparison of demand ratios at the study hospitals with corresponding statistics from other health care systems and CHAMPUS shows that the BLHC System does not entirely serve the demands of the non-military beneficiaries. While this result may be partially explained by existing DoD instructions or by constraints on funding, it does indicate unmet demands and by inference, unmet health care needs.

As a method of determining patient care requirements based on population projections, the Demand Model is superior to historical workload on the grounds of prediction and rationality. The numbers generated from the data that were made available demonstrate the feasibility of the Demand Model.

The Demand Model begins with demography of a base's mission, regional factors, and a projection of beneficiary populations. For inpatients, the output is admissions, census in each level of dependency, and ancillary usage; for outpatients, it is visits by major specialty clinic and ancillary usage.

At its present state of development, the more aggregated numbers have wider immediate applicability than the detailed numbers. Existing sources of data on BLHCS populations have been shown. Reporting or sampling of CHAMPUS claims by small geographic areas will also allow determination of

unmet health care demands of the non-military beneficiaries. To further refine the Demand Model, data collection in existing BLHC Systems should be undertaken to improve the present number, and extend the structure to show ancillary usage by level of dependency and by specialty clinic visit.

In applying the Demand Model to a specific BLHC System, data must be collected on patient dependency, clinic distribution, and ancillary usage to discover the details of medical practice for that facility. Moreover, before the Demand Model is applied to specific BLHC Systems, the fraction of the potential non-military beneficiary demand that the Department of Defense wishes the BLHCS to serve, must be determined. Special demands, such as AeroVac holding and transfers, are added into the demands from the population at and around the BLHC System.

The Demand Model appears equally applicable to planning for regional or specialized health care facilities. In this case, the amount and types of demands falling within the scope of the center are determined by the health care planner. For each type of demand, the inpatient, outpatient, and ancillary patient care requirements are determined from studies of existing facilities as ratios in the tree structure shown on page 3.1-29. The Demand Model then operates on the amount of each type of demand to arrive at the overall patient care requirements.

In summary, the Demand Model has been shown as a feasible and superior alternative method for planning in a BLHC System. For an entirely new BLHC System, the Demand Model allows by simple computations a prediction of the patient care requirements from a base's mission and projected population. In the more common case of a proposed expansion of a BLHC System, methods to better define the population at a BLHC System have been shown and the demands not met at the BLHC System may be determined. Once a decision has been made as to the fraction of each beneficiary category to be served, the same computations are used to arrive at the predicted patient care requirements.

RECOMMENDATIONS

RECOMMENDATION	OBJECTIVE
(1) Replace historical workload as the basis for planning by a method based on population;	Better prediction of patient and health care requirements;
(2) Refine Westinghouse Demand Model;	Better tool for predicting patient and health care requirements;
(3) Utilize and investigate existing data sources to determine population around a BLHC System;	Utilize additional sources of data available and improve data for planning on the basis of population;
(4) Require the subcontractors to CHAMPUS to report on request CHAMPUS claims by zipcode	Determine unmet health care demands around a BLHC System.

SHORT TERM R&D (< 18 MONTHS)

TASK	OBJECTIVE
(1) Collect and analyze more data on ancillary usage, by level of dependency and by specialty outpatient clinic;	Better numbers for the Demand Model, and more detailed structure;
(2) Investigate the medical and administrative features of light care;	Better definitions of organization and facilities for active duty military;
(3) Conduct sampling to determine age-sex breakdown of non-military beneficiaries in BLHC Systems;	Determine variation in age-sex breakdowns and facilitate comparison of utilization with civilian health care systems;
(4) Investigate in-depth data sources for finding population around a BLHC System;	More definite input to Demand Model;
(5) Large scale sampling of medical records to determine patient care and health care requirements by major disease or condition as well as by beneficiary type;	Extend applicability of Demand Model to regional planning;

(6) Sampling of patients and interview of physicians to determine criteria for schedulability;	Improved ability to schedule while meeting patient care requirements;
(7) Implementation on a trial basis of predicting short term (1 week or less) patient care requirements.	Improved utilization and staff scheduling within the facility.
(8) Organization and functional structure of OPD	Inverse throughput, output and operational effectiveness of staff, services and facilities.

LONG-TERM R&D (> 18 MONTHS)

(1) Study means of implementing total health care record -- inpatient and outpatient combined.	Permit following sequences of care on a sample basis to suggest improvements in medical practice.

3.2 Systems Design Concepts

INTRODUCTION

The Westinghouse consortium has generated a new design logic which is responsive to the needs of the DoD in design, construction and operation of BLHC Systems. This logic is based on a systems analysis of the BLHC System developed against a background of intense interaction with all the multi-disciplinary professions represented in the consortium. The group developed a sound understanding of the overall medical, planning, and operational needs of both the BLHC System and civilian systems when, as part of the analysis, they helped to characterize the existing BLHC System as well as generate a portion of the state-of-the-art survey.

TECHNICAL APPROACH

The technical approach for the development of the design concept task focused on fulfilling the following specific objectives for the DoD:

(1) Define the optimal BLHCS configuration and supporting systems for a given beneficiary population, mission, and geographic location.

(2) Project the performance requirements for the system in terms of life cycle changes in demands and operational requirements; define the capabilities and flexibility required to permit response to changing demands.

(3) Identify the most effective functional organization for the BLHC System components in terms of horizontal and vertical interrelationships for the optimal configuration adjacencies.

(4) Determine the characteristics and support systems required within the sub-system components to accept the day-to-day operational variables in terms of loading and levels of patient dependency and to be capable of responding to changing life cycle demands.

(5) Illustrate and apply state of the art technology concepts to the BLHCS requirements to generate improved life cycle capabilities at reduced life cycle costs.

These results provide the framework towards implementing the next step of designing, constructing and operating the "New Generation of Military Hospitals" for a specific base location.

The general steps in the technical approach parallel the other study tasks and include:

(1) BLHC System characterization
- Operational and functional characteristics
- Sensitivities
- Problems

(2) Improvement analysis and general design concepts
- Criteria for improvements
- Illustration of objectives
- Results and conclusions

(3) Improvement recommendations and design concept application
- Application and evaluation of results
- Sensitivity analysis
- Recommendations.

The design methodology and analytical tools for planning BLHC Systems are general enough to absorb the broadest set of variables. The organization and components of the BLHC System must be decomposed to permit simultaneous analysis of the system's elements at all levels of activity for both functional and physical implications. The BLHC System was characterized for analysis as follows:

(1) The Functional Systems include all the activities relating to inpatient and ambulatory patient care, as well as clinic and service support.

(2) The Audit Trail for definition of requirements leads from the gross resource description (Macro) of the demand model output to the

actual space and environmental requirements for the unit of activity, such as the patient capsule and the physicians' work station in the clinics (Micro).

(3) The Physical Systems include the movement and communications elements, the adjacency organization of BLHC components, and the physical support systems which become organizing elements for the overall BLHC Systems, as well as the smaller scales of activity.

(4) The Macro System represents the system's aggregation into its major organizational components and permits the manipulation of these components into alternative organizations for evaluation.

(5) The Micro System represents the individual units of activity aggregated into their functional elements and related to the movement and communications of the BLHC System.

The methodology permits the analysis of any part of the BLHC System to the level of detail indicated within this interrelated framework. The analysis was, in fact, focused on those components and activities identified as problem areas in the data gathering effort and where potential improvements could be realized within the project cost/benefit framework.

BLHC SYSTEM CHARACTERIZATION

The overall character of the BLHCS has already been described in the introduction to the analysis. Further refinements of this characterization, however, are required in those areas of medical practice, state-of-the-art, and operations which specifically impact on design and construction. The major data sources for the Data Gathering and Work Sampling Study Teams were:

(1) On-site visits to primary and secondary BLHC Systems as well as civilian hospitals;

(2) Discussions and working sessions with other members of the consortium;

(3) State-of-the-art surveys.

The Medical Health Care Team Report and Health Care Trends

The Medical Health Care Review Team report discusses the facility observed in the three primary study hospitals (Beaufort, Andrews, Fort Dix). Because these BLHC Systems are ten to twenty years old, Team findings were supplemented by on-site visits of the newest BLHC Systems. Most of the specific facilities recommendations of the Medical Health Care Review Team are incorporated as elements of the configuration improvement concept; these will be highlighted in the systems application sections.

In addition to the Team recommendations, expert consultants throughout the country gave their opinions of future trends in their fields in an attempt to determine the following:

(1) New services which might be required from the BLHC System.

(2) Services which might be eliminated due to medical advancements.

(3) Changes in practices and techniques in procedures such as surgery and radiology.

(4) Technology changes in laboratory tests and requirements for new tests.

(5) Changes of management and staffing patterns including new health professional and technical personnel.

The resulting trends were arrayed by their impending impact on the BLHC System by 1972, 1975, or 1980, and by their impact on the various activities, including inpatient, ambulatory, clinical support, and service support. The following list of trends has direct impact on planning, design, and future dynamics of the BLHC Systems:

	1972	1975	1980
(1) Graduated care within nursing unit.	X		
(2) Greater use of ward secretaries as ward managers.	X		

		1972	1975	1980
(3)	Triage as the point of entry into the health care system; OPD becomes the diagnostic and referral center.	X		
(4)	Increased use of ambulatory care centers inside and outside the composite facility.	X		
(5)	Outpatient surgery.	X		
(6)	Use of disposable surgical operating units.		X	
(7)	Development of automatic X-ray equipment (setting of controls and exposure time).		X	
(8)	Use of remote control fluoroscope equipment.		X	
(9)	Stapling in place of sutures to speed up surgical procedures (some by 50 percent).		X	
(10)	Increased patient education (preventive medicine) in waiting rooms and elsewhere.		X	
(11)	Availability of new vaccines eliminating mumps, measles, and meningitis.			X
(12)	Increased longevity due to heart valves and other technology (pacer implants, dialysis, etc.) with need for new services.			X
(13)	Multiphasic testing directed toward special age groups or possible disease conditions.			X
(14)	Centralized medical records storage for data such as admissions and abstracts.			X

	1972	1975	1980
(15) Computerized branching, automated techniques in clinical laboratory leading to logical surveillance of tests being automatically performed.			X

Since the trends related to 1972-75 affect the BLHCS design directly, the Medical Team evaluated their appropriateness for BLHCS application. The trends in the 1975-80 time frame relate primarily to future guidelines and criteria for design. For example, a significant reduction of time per surgical procedure has a direct impact on the number of suites for a given size System. Degrees of automation in clinical laboratories will affect the size and equipment of future laboratory design. Identification of these trends allowed the Design Team to consider the implications of these changes and to ensure that the entire system (or major elements) will be responsive to these changes.

After the data and the linkages were understood and quantified, the system was simulated as a function of time to reflect new demand dynamics, changed utilization policies, or changed health care trends. For example, changing health care trends and utilizations can be illustrated in the life cycle of the older BLHC Systems. Outpatient departments are traditionally ancillary services within a hierarchical health care system oriented to inpatient care. Current BLHC Systems reflect the trend toward increased ambulatory service demands (Figure 3.2-1). Future systems (Figure 3.2-2) will reinforce this trend with the availability of increased diagnostic and treatment services, such as outpatient surgery and the introduction of preventive medicine or family clinics for civilian components of the beneficiary population.

<u>BLHC Study Team Data</u>

Data elements developed for the three sizes of BLHC Systems include:

(1) Patient Flow

- Into the system (scheduled, unscheduled)
- Through the system (sensitive, non-sensitive)

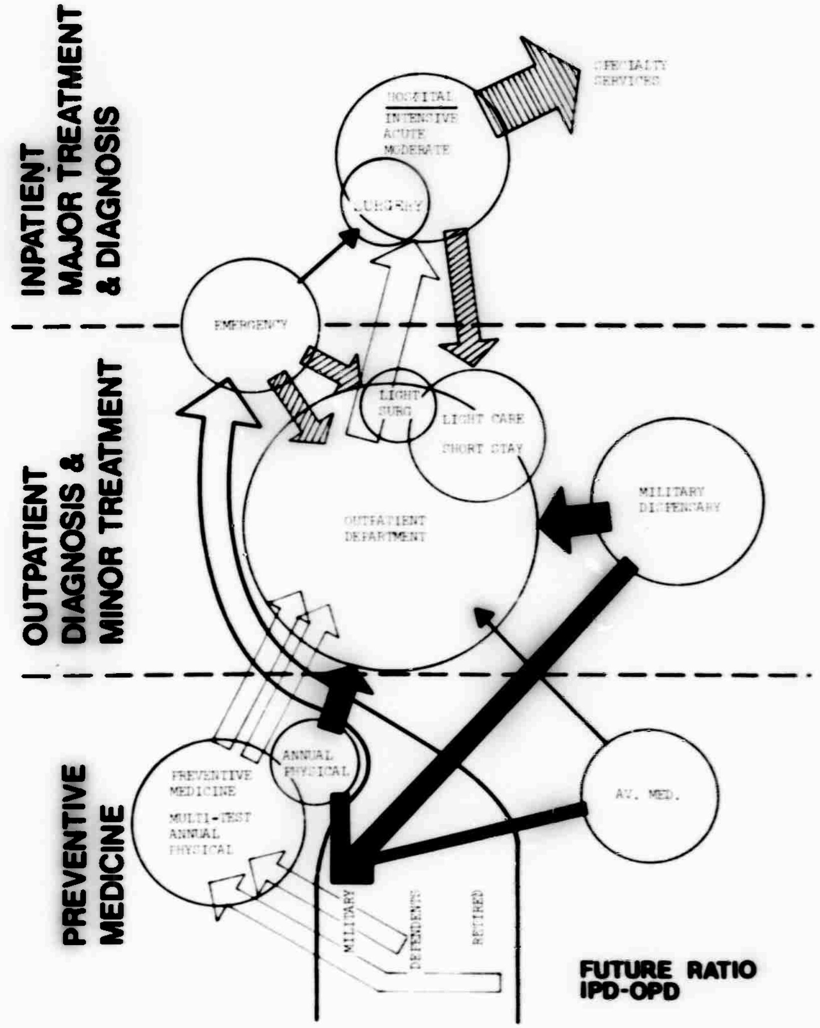


Figure 3.2-2 – BLHC Configuration Alternatives,
Future Ratio IPD-OPD

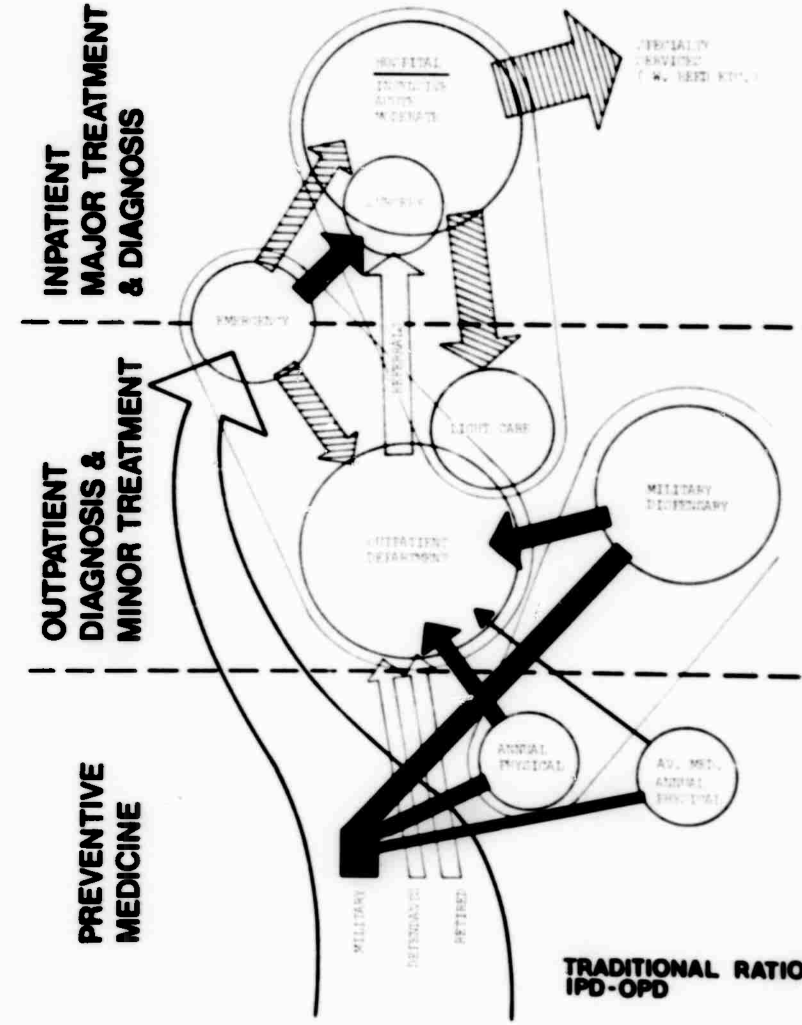


Figure 3.2-1 – BLHC Configuration Alternatives
Traditional Ratio IPD-OPD

(2) Staff Flow

- Physician
- Nurse
- Paramedical

(3) Communications Flow

- Volume (per day, per month)
- Nature (patient care, administrative, housekeeping)
- Origin/destination
- Urgency (patient care urgent, important, routine)
- Mode (hand-carried, telephone, other)

(4) Materiel Flow

- Requirements (by department, by volume)
- Frequency (scheduled, unscheduled)
- Time of day

These flows represent the major activities and dynamics of the operation of the BLHC System. The ability to quantify these flows enables the designer to analyze the linkage interrelationships and assign the appropriate performance characteristics to each link. The next step in the process aims at improved adjacency relationships and operational characteristics. Potential demand changes and system sensitivity can then be evaluated in terms of potential demand, dynamics, and changing utilization policies or health care trends.

Patient Entry

The BLHC System can be defined as the demand/resources interface where health care demands of the beneficiary population are served by the BLHC resources (Figure 3.2-3). The most important element in the BLHC System is the patient flow into and through the system. The entry of the patient triggers the application of system resources including equipment, staff, facilities, and management. Each patient entry results in demand for a sequence of care; this care varies according to the level of patient dependency.

Figure 3.2-4 relates patient entry and condition to the specific facility elements of the BLHC System. By assigning patient data to each branch of the decision tree, overloads and misuse of specific elements of the system can be identified. Further data analysis indicates the ability of the system to be scheduled and regulated if the appropriate level of resources match the health care demand generated by the beneficiary population. However, in the absence of resources to meet the demand, scheduling restrains the system and is circumvented by the non-scheduled entry of patients into the emergency or walk-in clinics. This places the primary demand on sorting functions with further unscheduled impact on the treatment and diagnostic activities.

Figure 3.2-5 illustrates the entry of the beneficiary population into the BLHCS. This diagram directly relates to the capabilities and input/output functions of the Westinghouse Demand Model by which any specific BLHC System can be modeled given the base mission and beneficiary population. The input/output function defines where patients enter the system: that is, to ambulatory services or to the various inpatient levels. Based on these data the demand on the ancillary services (diagnostic and treatment facilities) such as Radiology, Clinical Laboratory, and Surgery can be defined in numbers of procedures and tests by inpatients and outpatients. To further characterize system needs, these services can also be expressed as demand by type and frequency of patient care episodes.

The flows within the BLHC System are further analyzed to show patterns of interaction between departments and resources. The data gathering effort has provided the following information:

(1) Ambulatory inpatient admissions

(2) Ambulatory inpatient flow

(3) Emergency admissions

(4) Inpatient flow of a sensitive or urgent nature

(5) Inpatient flow as a function of patient care sequence from intensive to light care.

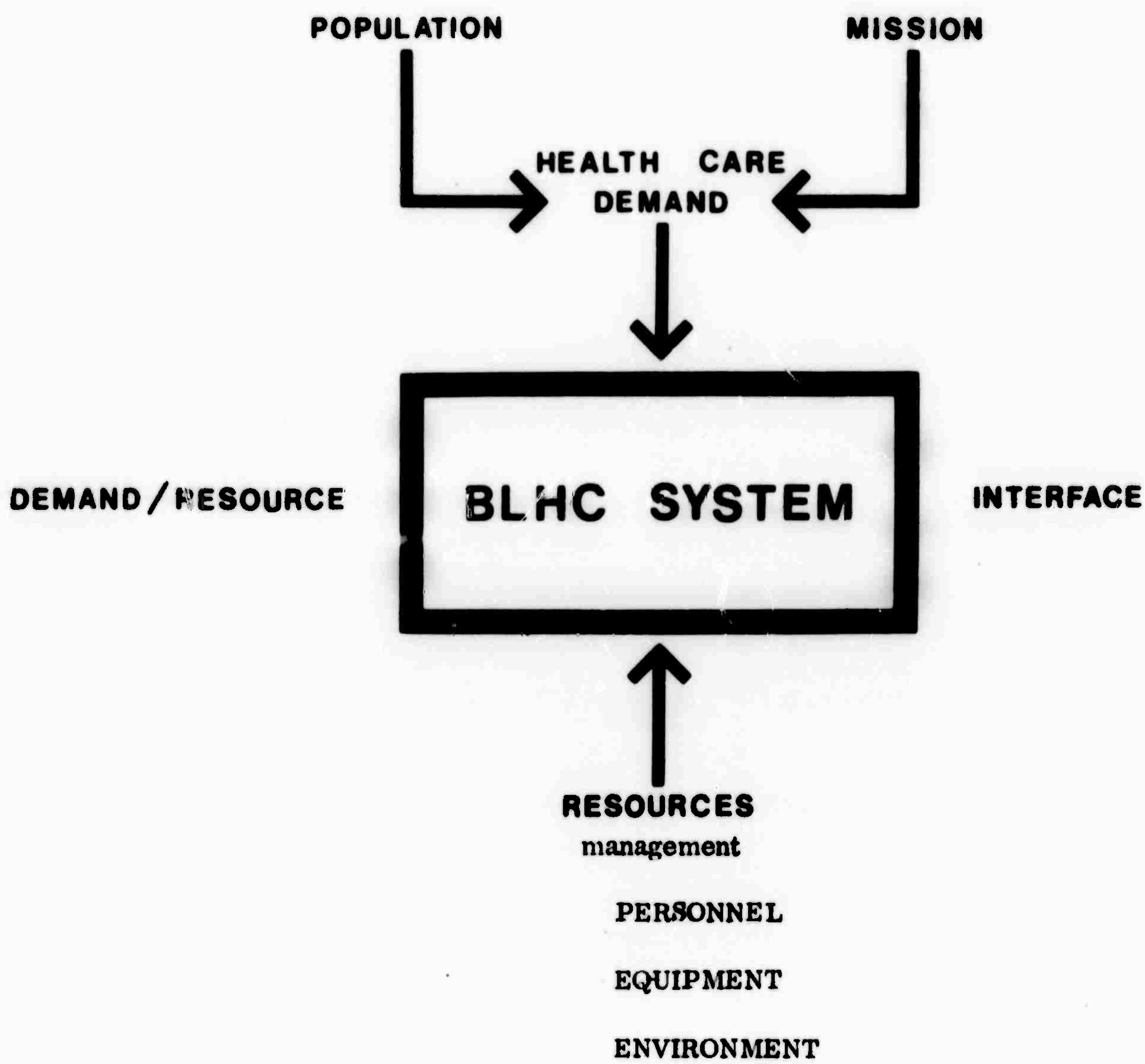


Figure 3.2-3 – Base Level Health Care System (BLHCS) Definition

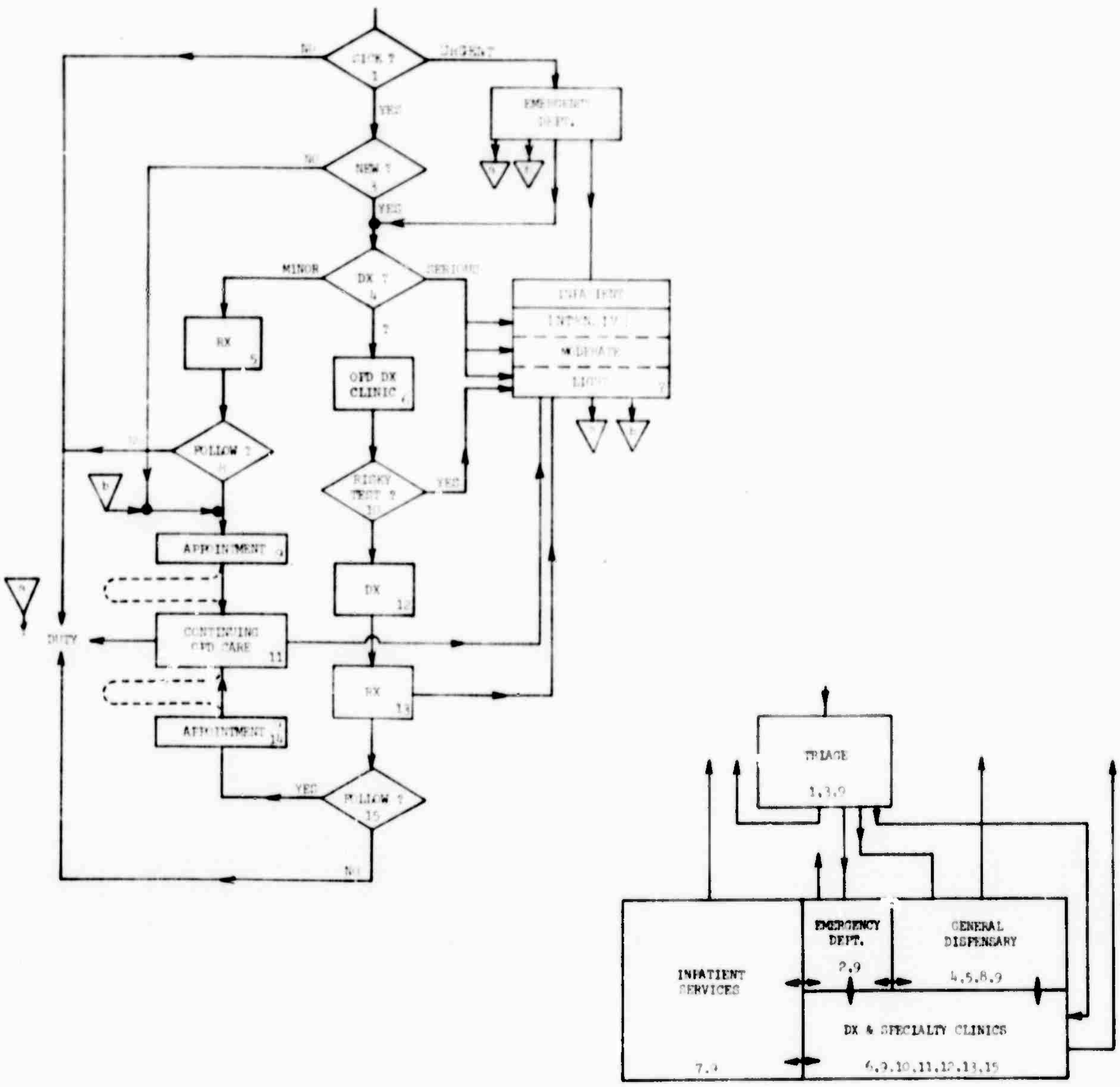


Figure 3.2-4 – Decisions and Facilities in BLHC System

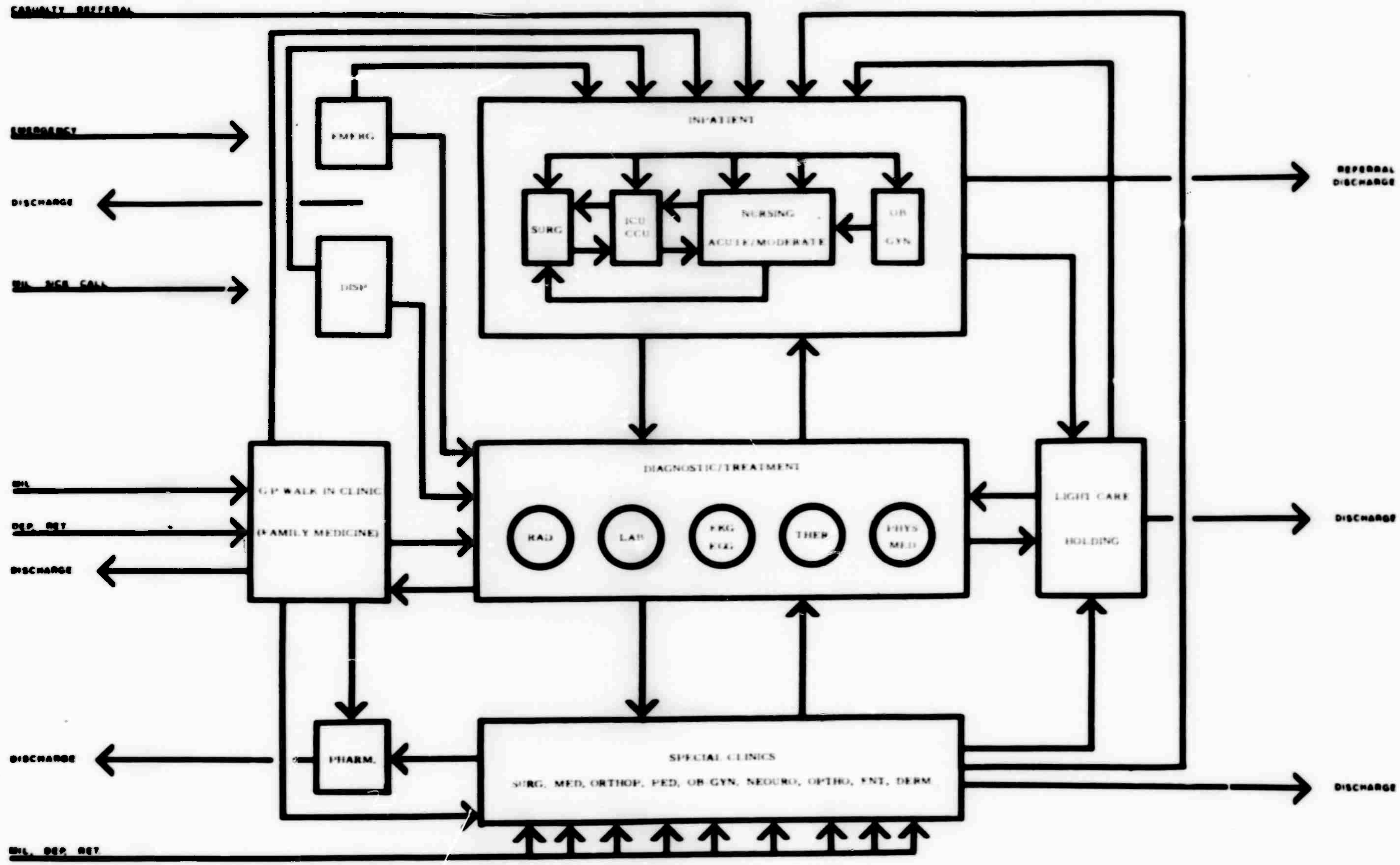


FIGURE 3.2-5 - SYSTEM ENTRY AND FLOW

Each of these flows generates requirements for functional relationships and the availability of resources and services at each functional location. The degree of urgency with which the patient and resources must be brought together are the factors which influence the response at the functional levels. The organization and functional relationships of the flow of staff, communications, and materiel define the primary zones of activity for the BLHC System.

These zones relate to the patient care and service activities as follows:

(1) The ambulatory zone contains all elements of ambulatory services for outpatients, the diagnostic and support services which serve both inpatient and outpatients, and the Emergency Department.

(2) The medical professional zone contains areas requiring the most complex technology for patient care areas such as Surgery, Delivery, Intensive Care, Coronary Care, Nursery, as well as elements of professional administration and Education and Training.

(3) The inpatient zone is defined by levels of inpatient care from acute and heavy to light care.

(4) The service zone houses the support elements such as Dietary, Warehousing, and Housekeeping.

(5) The mechanical zone contains the major mechanical services required to maintain the BLHC System.

In Figures 3.2-6 through 3.2-8, the inpatient flow patterns of the three primary study BLHC Systems reflect the flows into the functional areas of the various zones. The patient flow volumes represent annual flows between zones. These data can be readily interpreted into appropriate units of time (per day, time per day, time of day), which, for example, can be related to queuing in the Radiology Department and the specialty clinics, vertical transportation requirements for ambulatory inpatients at meal time, and the sensitive patient flows from the inpatient zone to surgery.

The diagrams illustrate a unique system characteristic in which a large ambulatory inpatient flow to dietary and treatment facilities places a significant

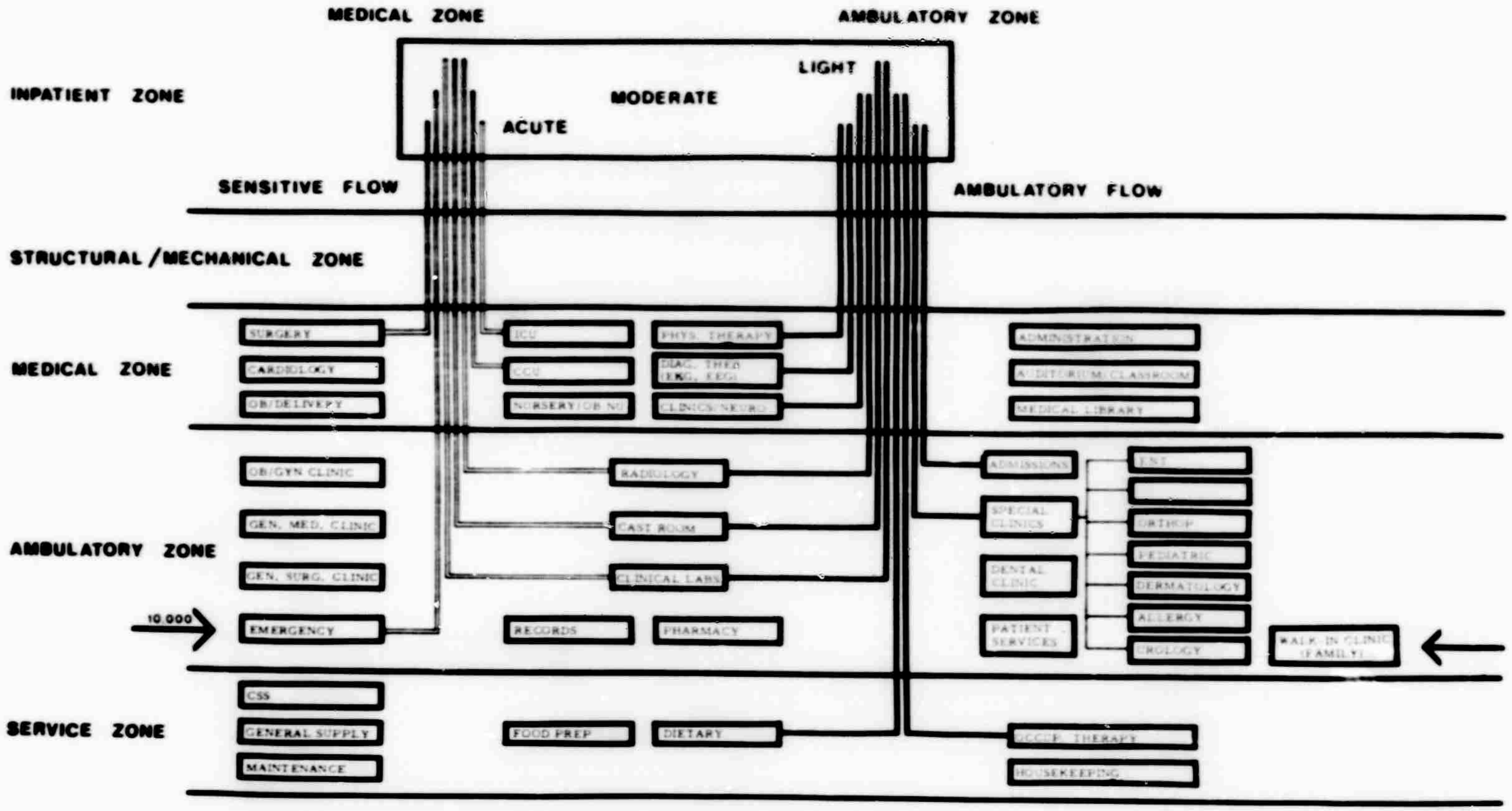


FIGURE 3.2-6. INPATIENT FLOW, BEAUFORT

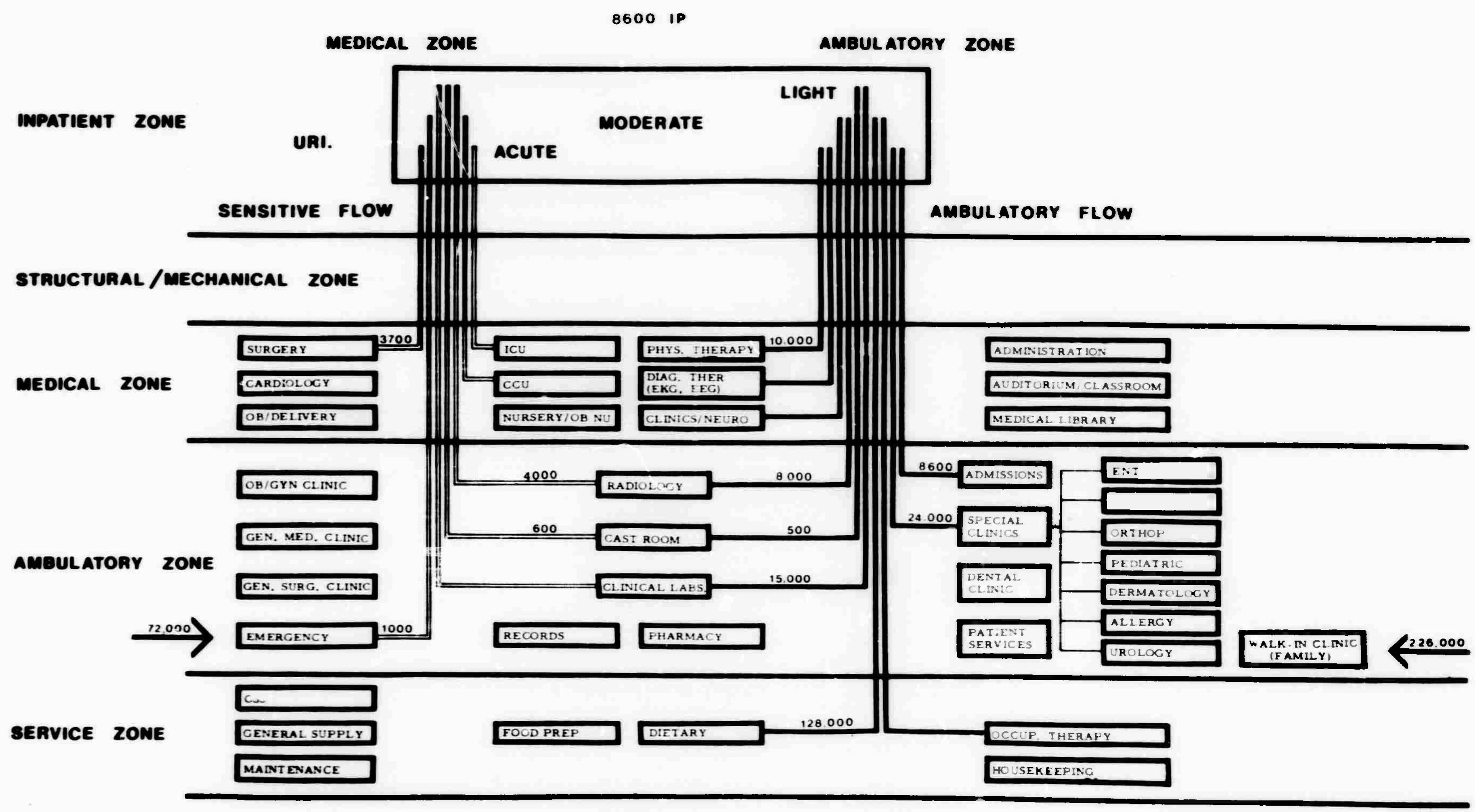


Figure 3.2-7 – Inpatient Flow, Andrews AFB

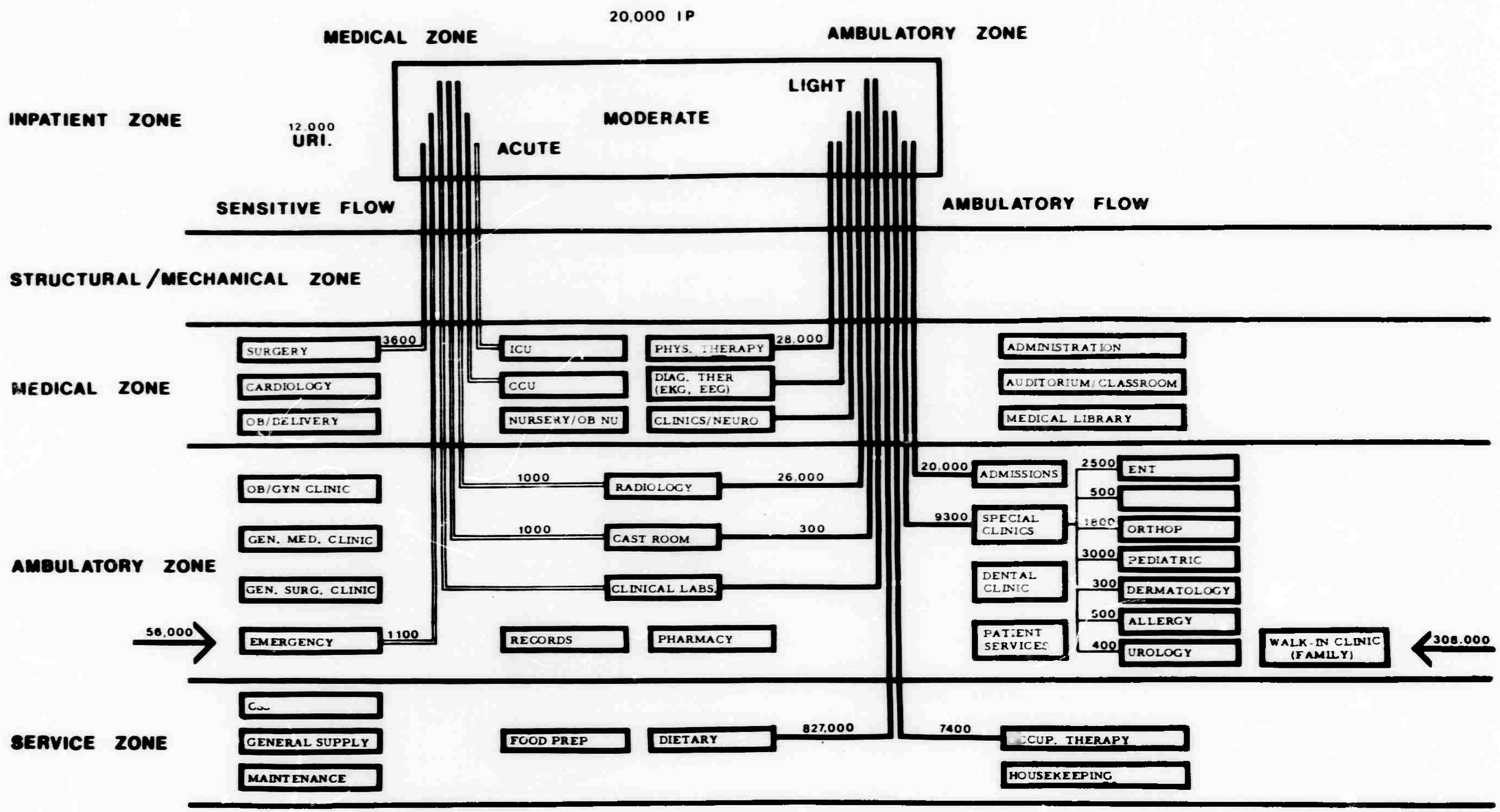


Figure 3.2-8 – Inpatient Flow, Fort Dix

demand on the vertical transportation capability. Since the patient goes to the service instead of service being brought to the patient, a tradeoff results in the materiel handling requirements. However, the character of the system can change during its life cycle; Malcolm Grow Hospital, for example, has a more acute inpatient population with a correspondingly lower inpatient ambulatory flow. Design, therefore, must be capable of responding to such changes in life cycle characteristics.

The first steps toward the new organizational logic for the improved BLHC Systems design are:

(1) Structuring data into redefined major zones.

(2) Relating vertical and horizontal adjacency relationships of the functional areas to flows.

Staff Flow

The staff flow data were used to refine the discrete adjacency relationships of the functional elements of the BLHC System. These data also related directly to communications flow, since the BLHC Systems studied primarily used hand-carried communications, which create staff flow requirements. Staff flow data, by type of staff, were based on work sampling and observations in the primary study hospital. Detailed movements of each type of staff were noted to and from each major functional area and were refined to develop movement data within the elements. Technology, as a function of time, was further superimposed on the patterns of staff movement. Information transmission through various electronic media should reduce much of the volume staff flow, and adjacency relationships derived from the present staff flow patterns may not need to be fixed throughout the life cycle of the BLHC System. However, the activities zones within which the movement of highly skilled personnel can be optimized will remain constant.

Communications Flow

To characterize all important communication flows in the BLHC System, data were generated on the following:

(1) Origin and destination

(2) Mode of communications

(3) Urgency

(4) Purpose

(5) Value and cost.

These data were arrayed in several forms; the most valuable for design is illustrated in Figure 3.2-9. This diagram show, ɩe number and type of communications observed during one month for the Outpatient Clinics at Andrews BLHC System. These data are also arrayed in a more complex form showing the purpose, urgency, and volume of communications in Volume V, Data Inventory of this final report.

By correlating the data across the three BLHC Systems, the high volume links between each functional element were defined; these, in turn, were useful in refining the adjacency requirements for the system.

Materiel Flow

The materiel flow patterns for facilities in both primary and secondary study systems were characterized by the Sybron Corporation; the methodology is described in a separate report on distribution systems. Materiel flow activity plans, derived from these data for three sizes of inpatient systems (250, 500, 750 beds) were further refined by testing the sensitivity of the activity plans for different mixes of inpatient care levels. Figures 3.2-10 and 3.2-11 illustrate the differential between the activity summary for a 250-bed facility with a "normal" inpatient population and one with a 50 percent ambulatory inpatient population. The heavily ambulatory system shows a 10.6 percent reduction of trips per day and a 13.4 percent reduction in the volume of cubic feet of materiel. Dietary accounts for 80 percent of the reduced number of trips and 94 percent of the reduced volume. Even with this reduction in trips

COMMUNICATION FLOW

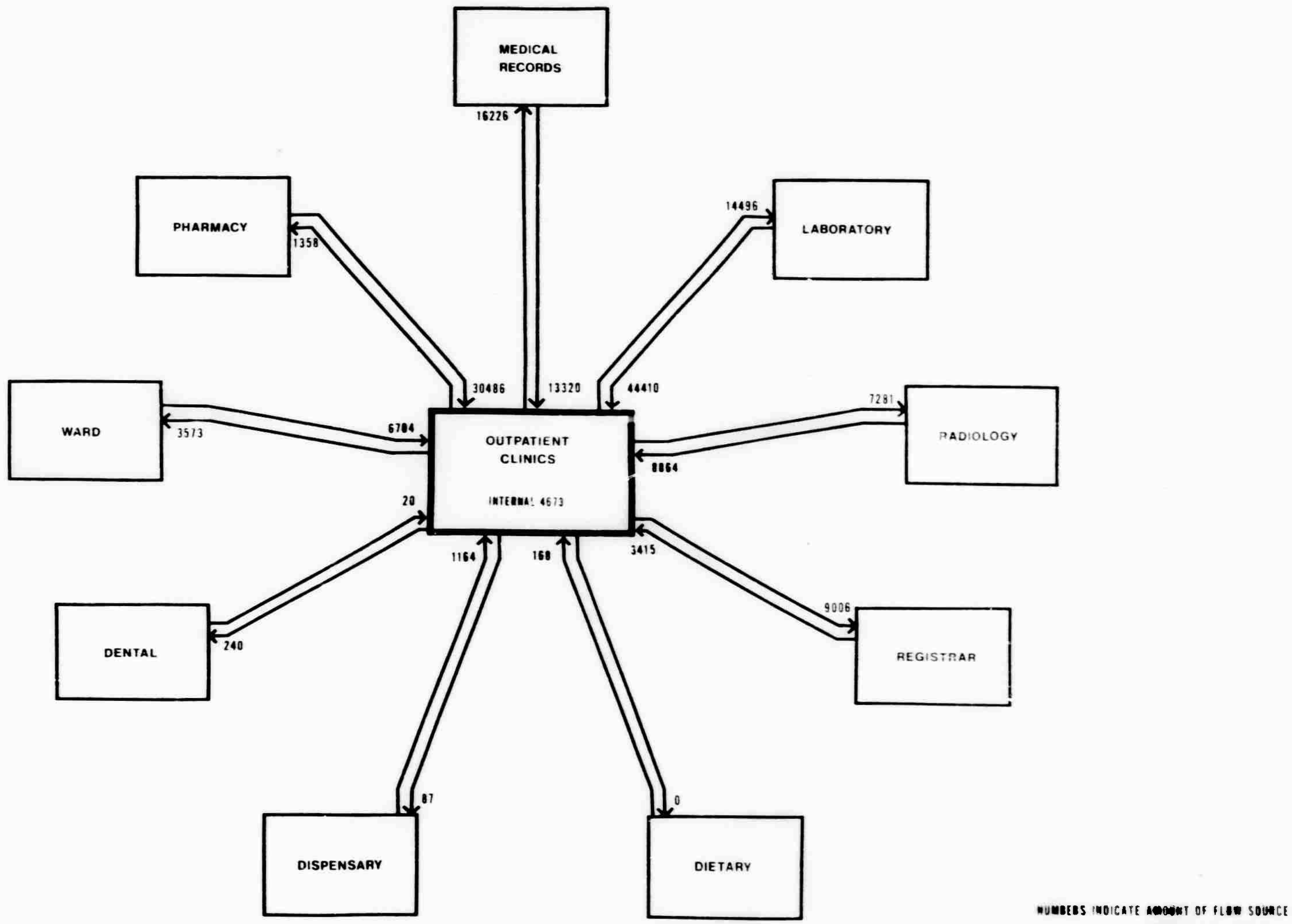


Figure 3.2-9 - Communications Flow Observed for Outpatient Clinics - Andrews BLHCS

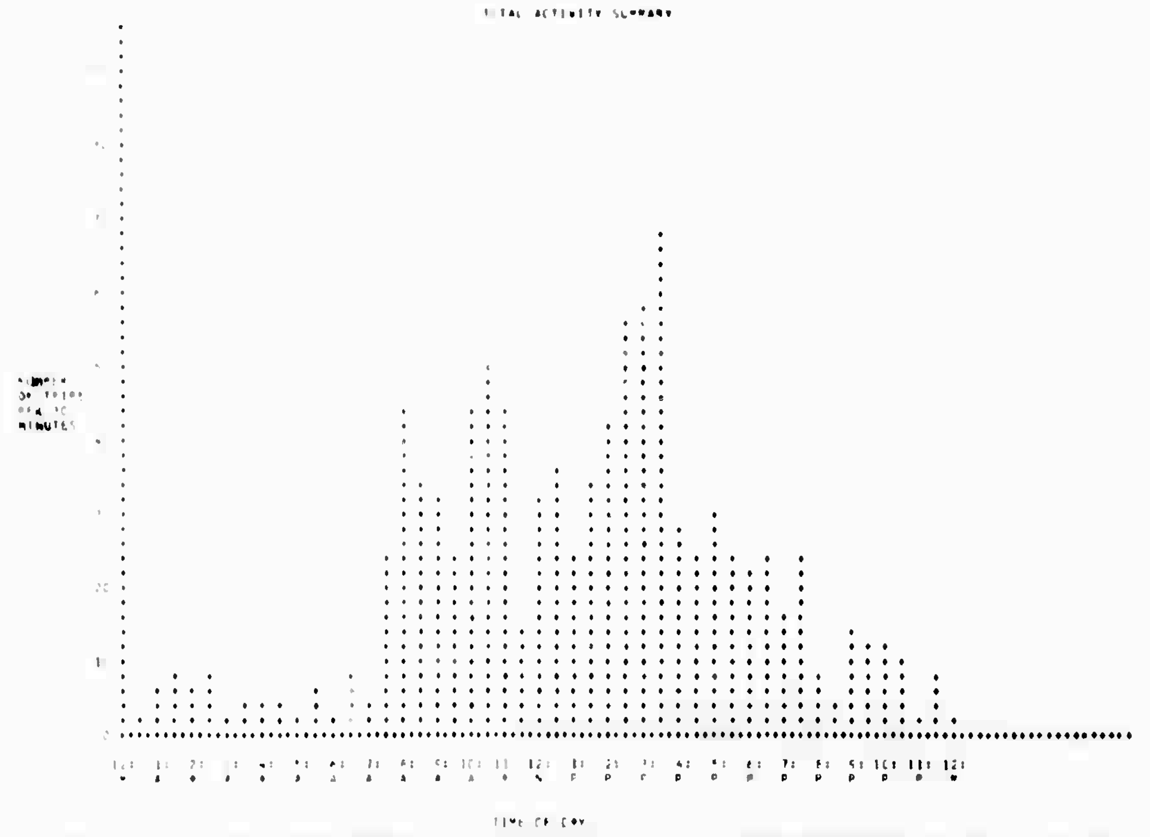


Figure 3.2-10 - 250 Bed Total Trip Summary - Conventional Configuration

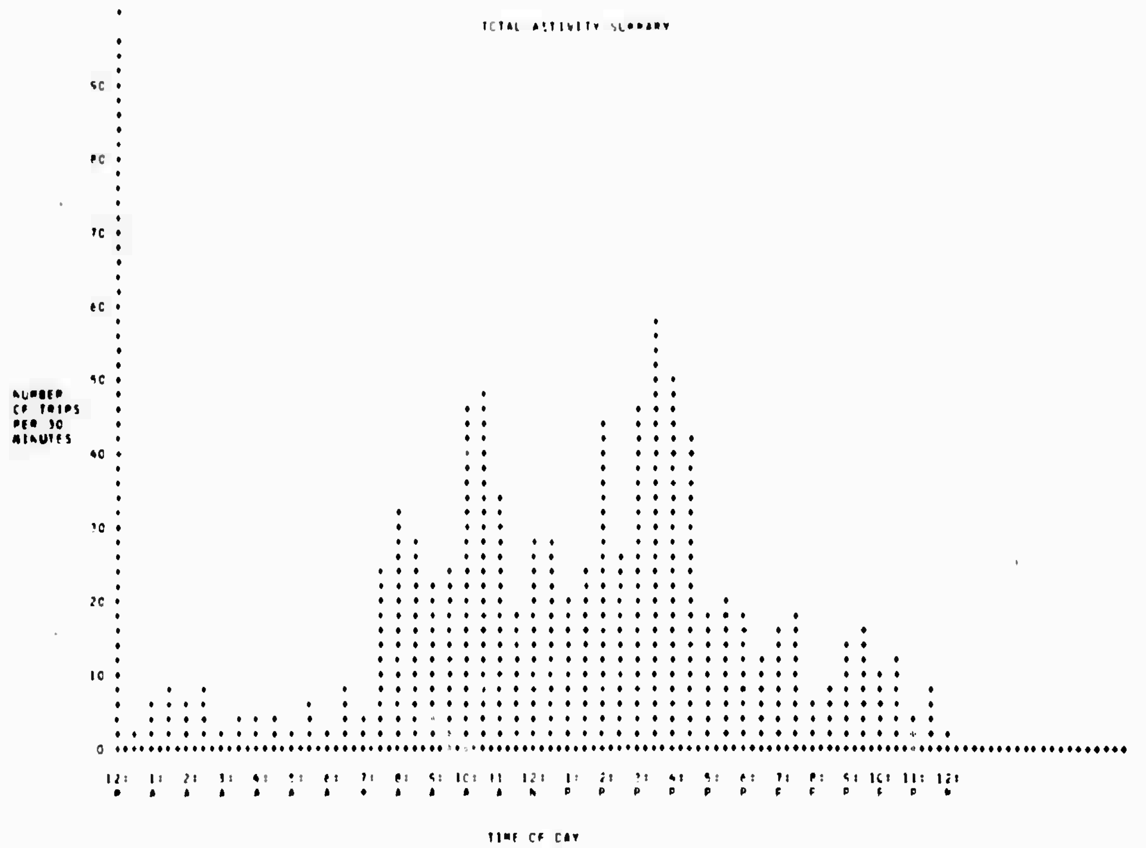


Figure 3.2-11 - 250 Bed Total Trip Summary - With Self-Care Separation

and volumes, dietary remains the highest generator of materiel handling activity observed across the BLHC Systems. In Tables 3.2-1, 3.2-2, 3.2-3, the five largest generators of trips and volumes are summarized by levels of inpatient size, showing one-way trips, and cubic feet of volume percent for departures and arrivals.

TABLE 3.2-1

One-way Trips Per Day (%)

250 Beds		500 Beds		750 Beds	
Functional Element		Functional Element		Functional Element	
Dietary	9.4	Dietary	10.4	Dietary	11.4
Linen	6.3	Linen	7.0	Linen	7.7
Maintenance	4.6	Maintenance	4.3	General Supply	3.7
Surgical Patients	4.6	Laboratory	3.8	Trash	3.7
Medical Patients	4.4	Trash	3.6	Maintenance	3.6

TABLE 3.2-2

Volume by Cubic Feet per Day (%) - Departures

Dietary	15.1	Dietary	15.6	Dietary	16.6
Linen	8.8	Linen	9.1	Linen	10.1
Surgical Patients	5.4	General Supply	4.8	General Supply	5.4
General Supply	5.1	Surgical Patients	3.1	CSS	3.3
Medical Patients	4.8	Medical Patients	3.1	Surgery	2.8

TABLE 3.2-3

Volume by Cubic Feet per Day (%) - Arrivals

250 Beds		500 Beds		750 Beds	
Functional Element		Functional Element		Functional Element	
Linen	12.7	Linen	13.4	Linen	14.0
Dietary	8.9	Dietary	9.7	Dietary	9.9
Trash	5.9	Trash	6.1	Trash	6.7
Surgical Patients	5.3	Food Waste	4.6	Food Waste	5.2
		CSS	4.6	CSS	4.8
Food Waste	4.8				

Figure 3.2-12 further refines this summary by a definition of the type and nature of the trip.

The key to interpret these summaries is as follows:

(1) Type 0 trips are one-way trips which originate with a full or empty container, make a circuit of deliveries or pickups to successive destinations, and terminate at the point of origin with an empty or full container. An example of this type of trip is a pharmacy delivery or laboratory sample pickup.

(2) Type 1 are two-way trips which originate with a full container and terminate at the point of origin without a container; for example, a dietary delivery from the kitchen to the inpatient areas.

(3) Type 2 trips begin with a full container and terminate at the point of origin with an empty container. An example of this two-way trip is a linen delivery. A refinement of this trip type which converts it to two type-3 trips (two productive one-way trips), is the delivery of a full container with clean linen and its return with soiled linen.

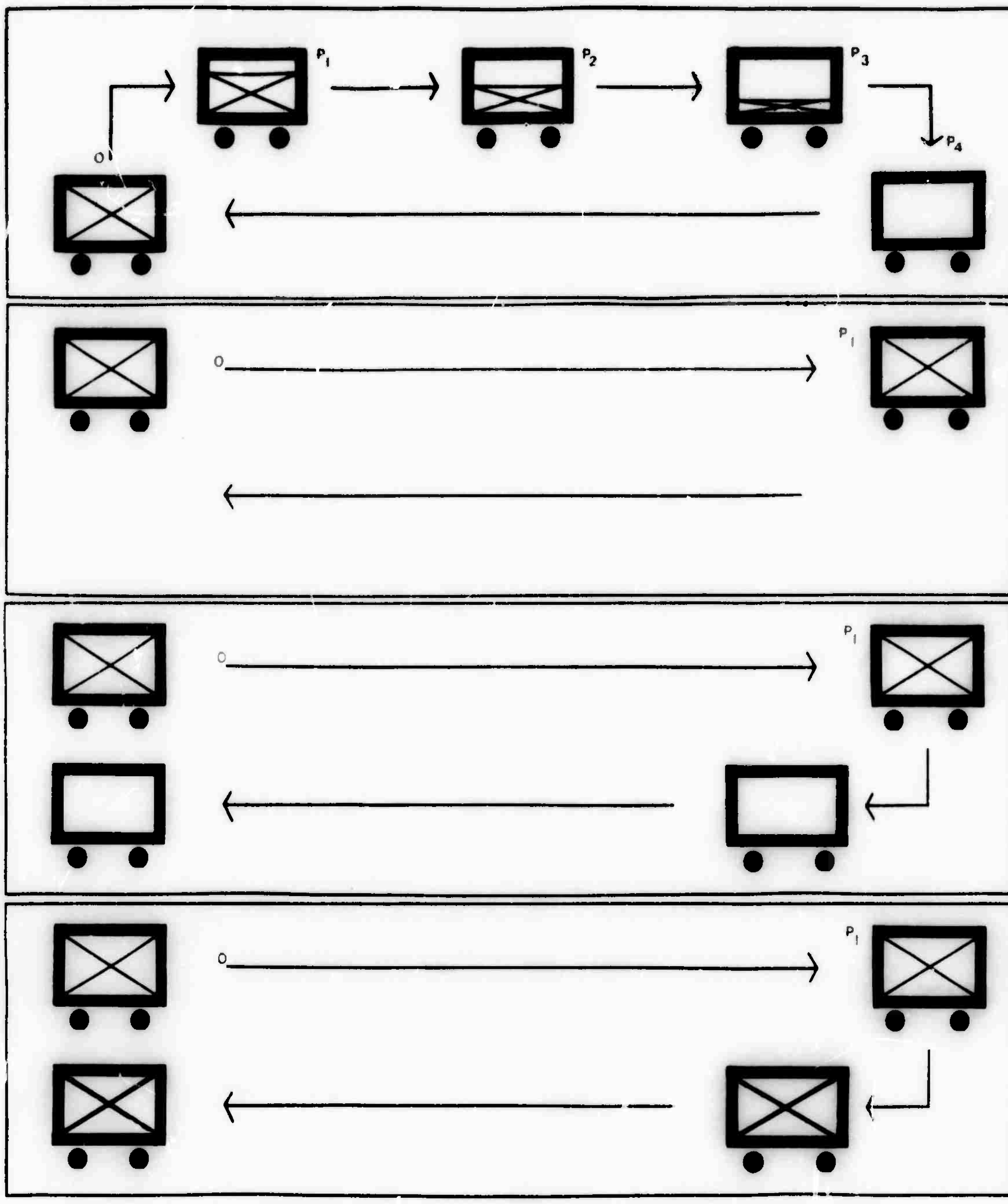


FIGURE 3.2-12 BLHCS MATERIEL DISTRIBUTION TRIP TYPES

(4) Type 3 trips originate with a full container and terminate at the point of origin with a full container; for example, an exchange cart system for linen or dietary. This counts as two productive one-way trips.

The activity per trip type for a 500-bed BLHC System is summarized in Figures 3.2-13 through 3.2-16.

Planning and Design Process

The present planning and design procedure is a two-stage process. For each service, health care planners present resource requirements calculated for a specific new BLHC System or desired requirements for upgrading an existing system. These resource requirements, stated as systems capabilities (such as number of beds, outpatient visits, and ancillary usage each year) have been calculated to match the health care needs of the population. These requirements are generally stated as a "static" quantity, representing the best estimate of demand.

The facility designers then convert each system capability into a detailed space program to be allocated to this element according to extremely detailed data in the current criteria. This space program relates the capability required (number of visits per year to a specialty clinic) to the individual components of that element through a set of performance criteria (the size and number of physicians' offices and examination rooms related to the average number of clinic visitors a physician attends per year). All supporting activities are aggregated within this system element (including the waiting, dressing rooms, toilets, and storage) based on the formulae in the criteria. All elements are then aggregated into a total statement of net space. In addition, certain factors are added to account for wall thicknesses; circulation between and in system elements; and mechanical, electrical and heating, and ventilation and air conditioning (HVAC) machinery spaces. The latest average cost per foot for hospitals currently allowed in the military is applied to this aggregation, creating the basis for a budget line item in the DoD requests for congressional funds.

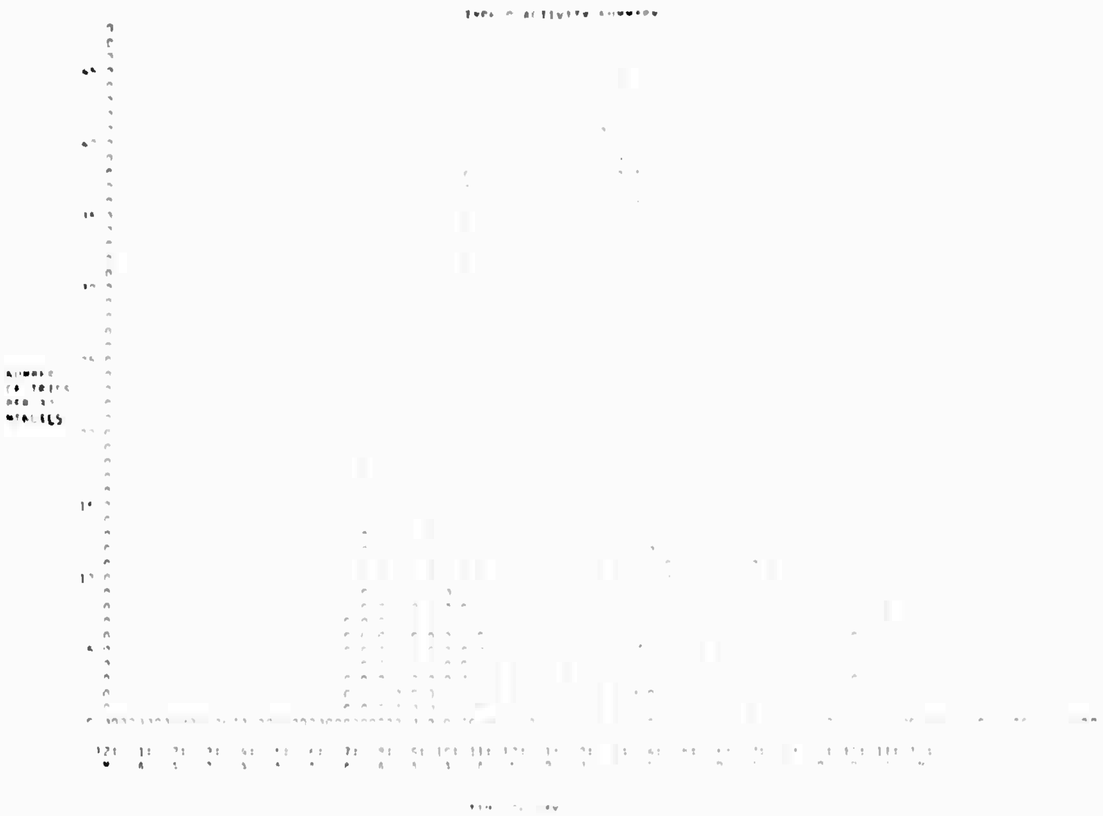


Figure 3.2-13 - Materiel Distribution Trip Types

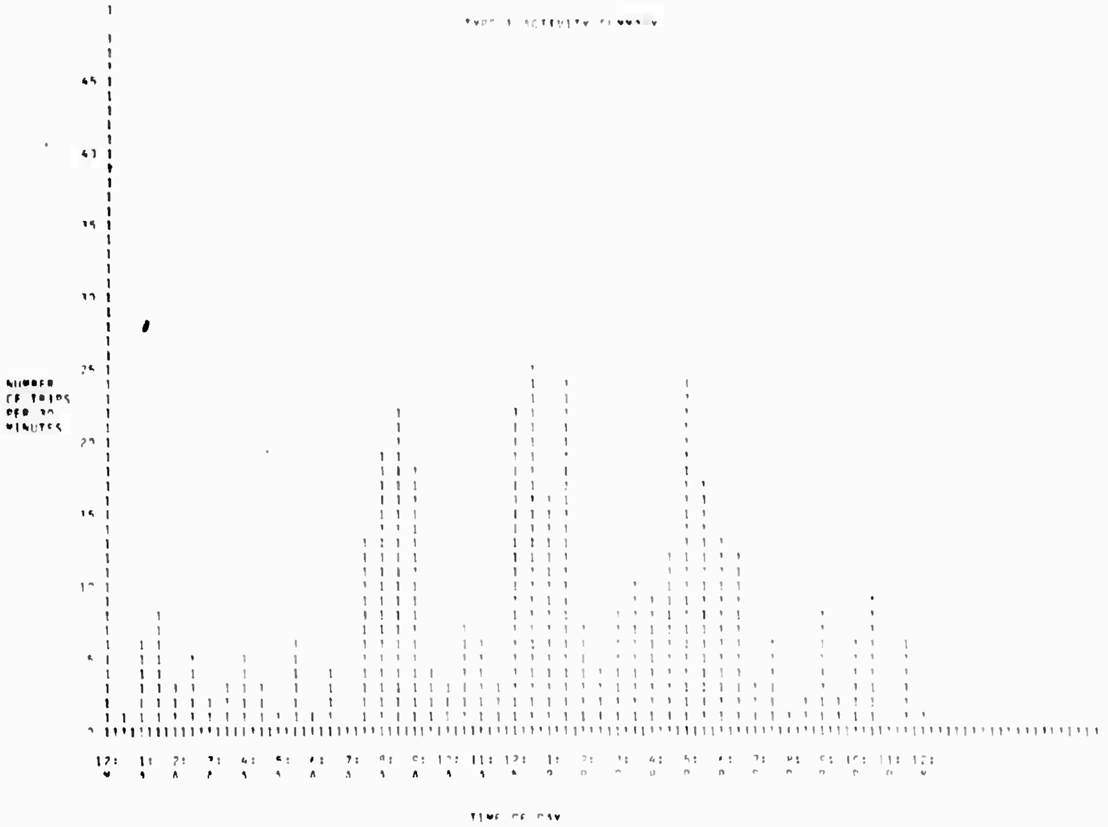


Figure 3.2-14 - Materiel Distribution Trip Types

Figure 3.2-15 - Materiel Distribution Trip Types

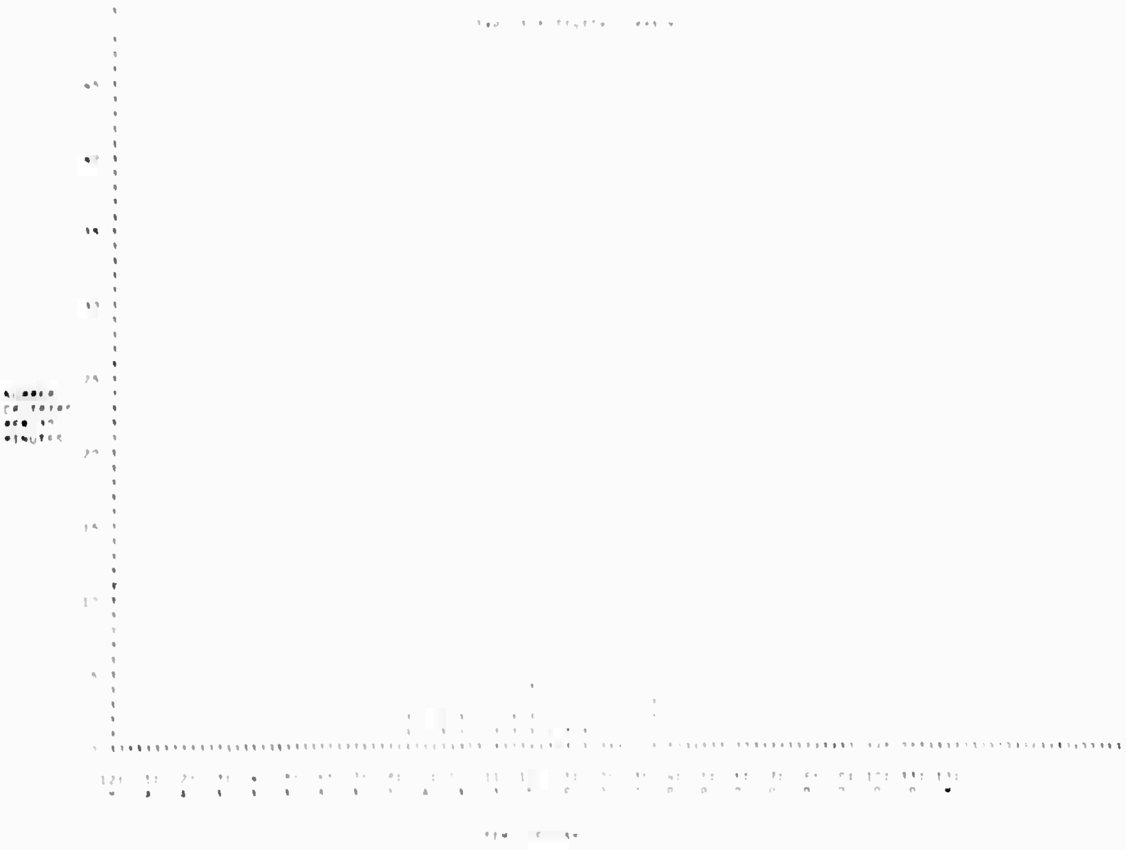


Figure 3.2-16 - Materiel Distribution Trip Types

Assuming that Congress approves this item, an architect is selected to execute a detailed design for construction. The architect is given the space program, budget limitations, and a design narrative containing some guidelines and data clarification. He may not be aware of the potential change and growth requirements which may have impact on the system.

The entire process to occupancy may take five to seven years, during which time perceived demands may already have exceeded the System's capability and the nature of the demand may also have changed. It is recognized that the present method of planning, programming and construction is beyond the control of the operating agencies, and subject to the constraints of executive and legislative procedures. Specifically, the time lag which is tied to congressional and committee reviews creates uncontrollable cost changes due to escalation. Similarly changing demands may not be adequately recognized in the line item which fixes the scope and cost of the project early in the cycle. The present process, therefore, is not sufficiently flexible to recognize changed program requirements during the elapsed time. The net result is a facility which may match the needs of initial demand and may be built for the budgeted first cost. Since it has been designed with inadequate data, however, certain operational constraints typically appear soon after occupancy.

Current BLHC systems have little capability to respond to these changes in requirements. They are equally insensitive to changes in demand caused by medical practice, such as increased demand for greater diagnostic assistance for a given disease incidence. More capability has generally been obtained by expanding into less essential adjacent space or building additional space. Large scale growth to accommodate mission changes has presented similar problems. Growth generally means disruption within the existing facility and a displacement of the original functional relationships. This often requires duplication of existing facilities resulting in higher operating costs.

In support of the data collected from primary and secondary BLHC Systems, additional data on all the CONUS base level facilities were obtained. The majority were found to have undergone extensive changes and growth during their life.

Identification of Problems

Based on the characterization of the BLHC System, the following major problem areas have been identified in facilities design:

(1) Present facilities are designed at a fixed point in time for a static program without specific capabilities to absorb changing and growing health care demands. A need exists for more accurate forecasting of health care requirements and the impact of change and growth on the design configuration.

(2) The current design process does not have the benefits of an extensive operations analysis of the BLHC System and, therefore, is not supported by an extensive data base. As a result, each System is forced to depend on the capabilities of each individual designer, his perception of the operational requirements of that system, and his sensitivity to the specific problems of the military health care delivery system.

(3) The planning, programming, and implementation cycle is too long and too sensitive to delays beyond the control of the system. The delays not only result in changing operational and demand characteristics but also in increased costs or reduced capability. The emphasis on least first cost results in compromises of operating efficiency and future capability. This ultimately leads to increased life cycle cost in both operations and acquisition costs.

(4) The functional space program is only one of the essential elements of design instruction. A comprehensive statement of current and future performance requirements for the total BLHC System as well as the individual sub-elements must support the program or the future capabilities and performance of the facility will be limited in terms of its response to new demand characteristics. The technological alternatives for various support systems must also be considered against life cycle costs and benefits.

(5) Time is the most critical element for all of these problem areas, since excessive elapsed time during planning and design results in changed requirements and available resources.

OBJECTIVES FOR THE DESIGN CONCEPT

After studying the design and construction processes used to generate the present BLHC Systems and identifying the major problems to be solved, three primary and seven corollary objectives in support of the primary objectives were developed:

Primary Objectives

(1) A design logic which is itself a major improvement alternative to the present method; its use and impact will be assessed against the variety of demands placed on the System over its life cycle, independently of other proposed alternatives.

(2) A design capable of responding to the performance requirements of the BLHCS for operational and life cycle system dynamics.

(3) A framework for testing the sub-systems and operational improvements alternatives being considered for the BLHCS.

Corollary Objectives

(1) A design logic which results in a facility based on an understanding of the major flows of patients, staff, materiel, and communications within the overall system and allows for optimizing these flows.

(2) A design logic which uses the quantifiable time and distance relationship, both horizontally and vertically, between different levels within the system to facilitate analysis of inter- and intra-element alternatives.

(3) A design logic capable of accepting a wide variety of system elements to match the needs of the BLHC System.

(4) A facility built as a result of this design logic at an initial cost comparable to that of an equivalent conventional BLHC System with a demonstrable life cycle cost saving over the conventional facility even when responding to the system's changes and growth.

(5) A design logic to achieve the following growth:

- <u>Inpatient Area</u>

  250 beds initially, 200 percent expansion

  500 beds initially, 100 percent expansion

  750 beds initially, 25 percent expansion

  This general framework of growth requires a design concept capable of a range of initial configuration options to satisfy any system requirements within the 250- to 750-bed BLHC Systems.

- <u>Outpatient Area and Clinical Support Services</u>

  Areas capable of discrete and unique growth related to each function, in response to accelerated or changing demands. Maximize the adaptability of these functions by providing facilities which are as universal as possible in their health care applications, free of fixed physical constraints, and flexible enough to use staff and equipment in varying combinations. This growth must be achieved within the organizational relationship of the initial facility, and ensure that those relationships which are forced to change will not impair patient care or high operational cost elements.

(6) A design logic capable of using a variety of construction technology including off-the-shelf technologies and selected applications of local materials and practices.

(7) A design logic less sensitive than the present process to the following issues:

- Errors in the statement of health care demands without major mission changes.
- Changes in technology.
- Changes in the practice of medicine.
- Changes in utilization policies.
- Changes in major missions requiring alteration of the former popluation mix and size.

MEASURES OF EFFECTIVENESS

As outlined in the introduction, this study identifies two measures of effectiveness -- prospective and retrospective. The ability to achieve these objectives using study outputs must be compared to observed current performance in the present BLHC System. The results of using conventional methods to achieve an objective must be estimated.

All design alternatives evaluated were arrayed against the following measures of effectiveness:

(1) Does it produce a system of greater or lesser sensitivity to change and growth?

(2) Does it allow for the growth and change limits established while holding the organizational relationship stable?

(3) Is the system responsive to the range of performance for all elements of BLHCS within 250, 500, and 750 inpatient sizes?

(4) Are the main activity zones sufficiently flexible to meet the demands of their own unique and interrelated dynamics within the system logic?

(5) Does it provide a faster and more explicit design and estimating process?

(6) Does the resulting facility cost more or less over its life cycle than an equivalent conventional facility with the same initial capability? How do their operating costs for providing the same health care compare?

(7) Does the facility have characteristics which will allow for change and growth at less construction cost than the equivalent conventional facility? How do the characteristics of each facility compare for:

- speed in accomplishing such changes and growth;
- degree of disruption to the day-to-day operations while achieving these changes;
- operating costs?

(8) Does the design solution offer the professional personnel and their support staff advantages in the delivery of health care?

SYNTHESIS OF ALTERNATIVES

In the first step of the synthesis of alternatives, the present methods of design and construction were arranged as alternatives, using as many definitive measures of its components as possible for a basis of comparison with proposed alternatives. However, the real issue was to find or create an alternative which meets all, or most of, the objectives for overcoming deficiencies in the present systems. Construction state-of-the-art represented the data base for identifying the best improvement alternatives over the present process. The The State-of-the-Art (Construction Section - Volume IV) presents alternatives which may be applicable. Two contenders which were considered as candidates for the system are:

1) Interstitial Space

The use of interstitial space is one alternative for designing a flexible facility with the least sensitivity to change. Unless it is used as part of a design process based on broad operational data, however, the functional elements cannot be optimized nor can the facility be more effective or less costly than a conventional BLHC System. This concept is best used when all parts of the facility have an equal requirement for change. Facilities currently using this approach have not solved the inherent problems either in the overall system, or in elements which have discrete requirements for growth. For many reasons, growth usually relates to duplication of major areas of the initial structure or, at best, a limited expansion into space provided but unoccupied in the initial layout. Finally, the high first cost incurred in construction cannot be justified by comparison to conventional facilities.

2) Modular Approach

The second major design contender, the "modular" approach, seeks to define a module of space which represents a specific system sub-element such as a surgery operating suite; once one module is designed, all others are some multiple of this space. While this approach allows the least construction cost for conversion of spaces into different uses, it ignores the fact that operating costs are the predominant costs in the life of a facility. Furthermore, these costs are adversely affected when major element interrelationships are changed.

Neither alternative fully responds to the requirements of the BLHC System. The design concept, therefore, does not suggest a direct application of either method, and in fact, represents an improvement in the current State-of-the-Art. In response to the unique requirements of the BLHC System, interstitial space application is limited to the mechanical servicc zone location only. However, its function is expanded to become: 1) thc structural transfer zone; and 2) integrates the service and housekeeping functions.

The concept of universal space modularity is rejected, and it is suggested that each functional area has unique modular characteristics, i.e., inpatient module - the patient capsule, nursing unit block (2 or 3 levels); ambulatory area - clinics, examining stations; surgery - suites; radiology - suites. The design concept provides for the growth and change of these in modular increments based on the Demand Model simulation and the Base "X" test example. However, the application of appropriate standardized building components is not precluded in the design concept.

One of the inherent concepts of a modular approach to flexibility is the interchangeability of spaces. Such interchange may result in displacement of adjacencies which were based on the functional characteristics of the system, and therefore can result in undesirable operational patterns.

NGMH Design Concept

To accommodate these limitations, a new design logic has been generated based on the detailed understanding of BLHC System requirements and/or the design objectives already stated. This design logic consists of developing an organizing logic which relates the four major activity zones to flows. Macro and Micro studies were also conducted to relate the system elements and sub-elements into this logic.

System of Organization

The organization of the BLHC System design logic is based on the functional and physical relationships and inter-relationships of all system

components and elements at the total systems scale(Macro) and at the patient care units of activity (Micro). Quantification and intensity of these relationships are a function of the BLHC System elements contained in the data base.

The organization system, based on the fundamental elements of health care includes:

(1) Patient flows

- Total patient entry, both scheduled and unscheduled
- Ambulatory patient flow
- Ambulatory inpatient flow
- Inpatient flow requiring an acute level of medical care (sensitive flow);

(2) Sequence of medical care from intensive to light and the extent to which these levels vary in the general BLHC populations.

(3) Zones of medical care intensity and the resources needed for various care intensity levels.

(4) Information flow, its urgency, and volume.

(5) Materiel flow, its urgency, and volume.

Patient flow is the most significant item, because patient entry into the system, scheduled or unscheduled, is the driving force to which the entire system must respond (Figure 3.2-17). Such patient flow triggers personnel and data flows to the interface points where medical care is provided. Somewhat less important to the system's overall performance is the flow of materiel to those interface points. These priorities were used as guidelines in developing the organization concept.

The sequence of health care is based on the progression of the patient through categories of dependency; these range from inpatient intensive, inpatient moderate and light, to ambulatory and outpatient. Zones of medical and service activity plus the resources of each treatment level relate to the sequence of health care. To accommodate the sequence, BLHC Systems were decomposed and restructured into four primary activity zones:

(1) The ambulatory zone at grade containing all outpatient clinics together with ancillary services such as Radiology, Clinical Laboratories, Pharmacy, and Emergency (Figure 3.2-17).

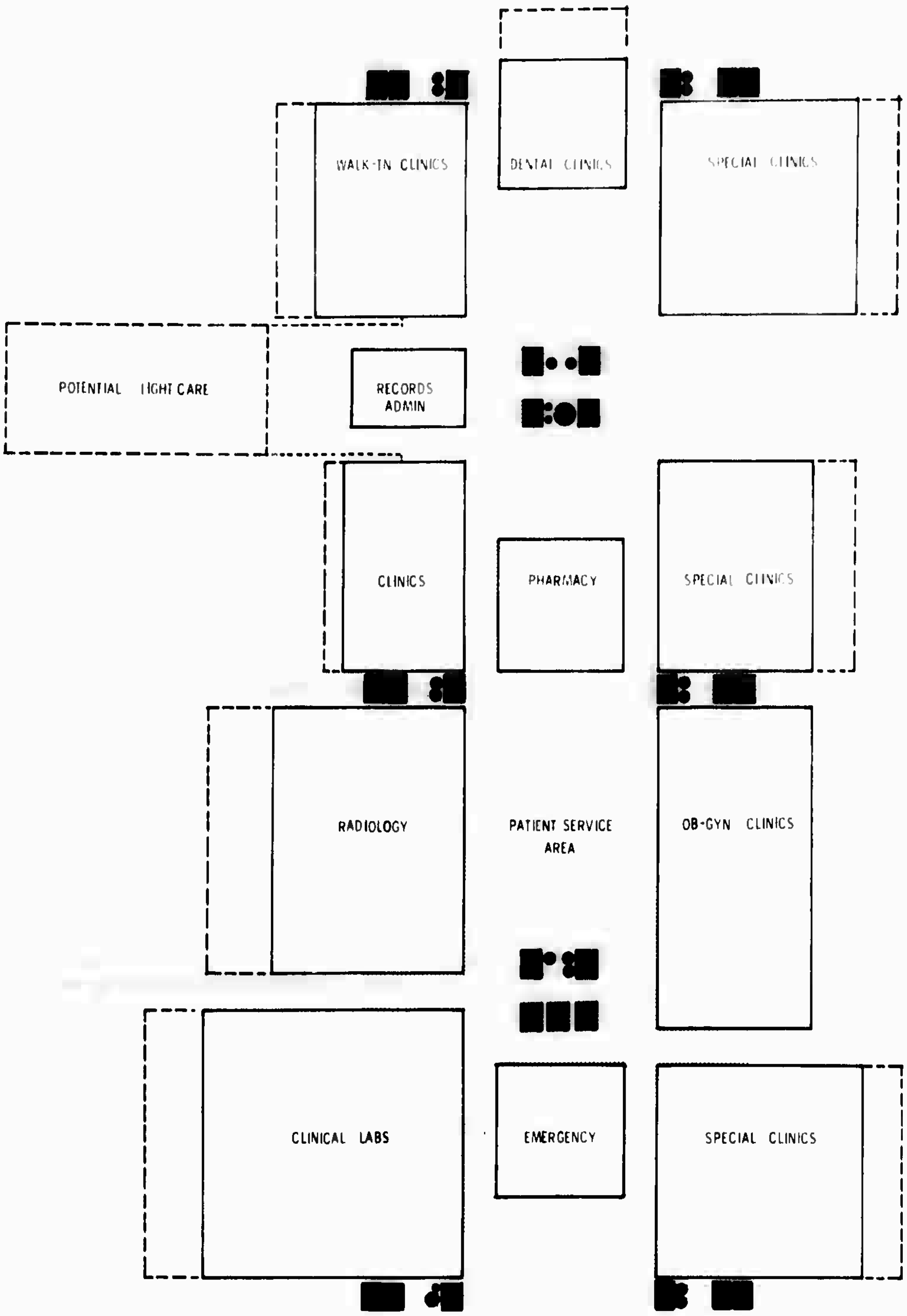


Figure 3.2-17 - Ambulatory Level

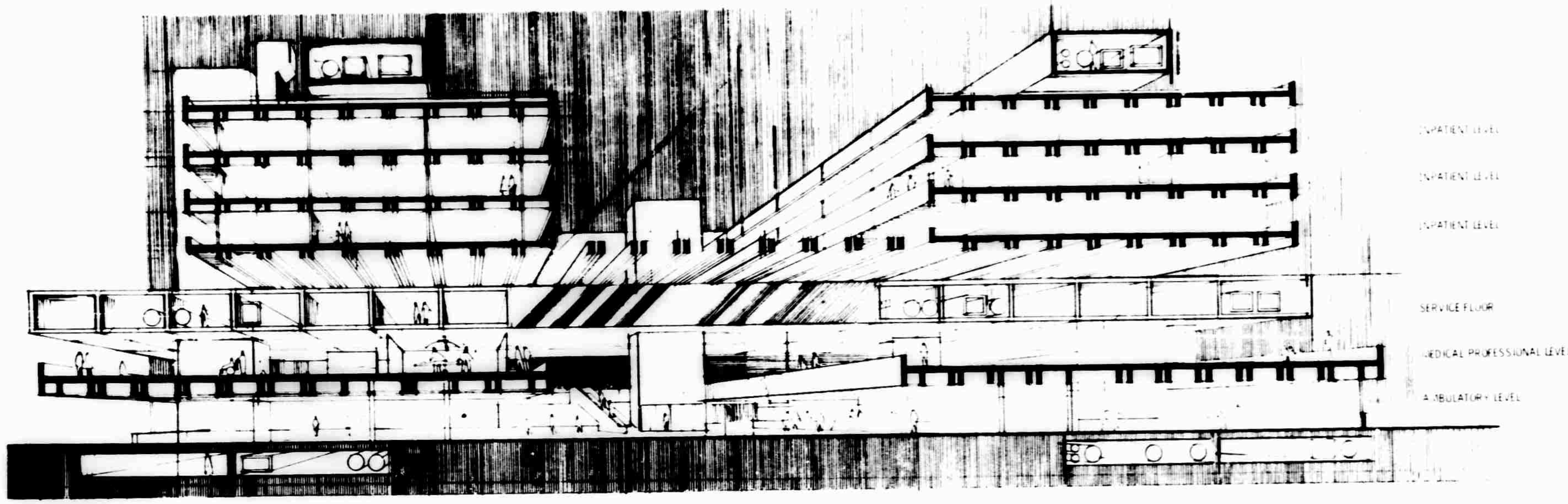


Figure 3.2-18 - Facility Configuration showing the Three Primary Activity Zones

(2) Medical and allied professional zone containing the high technology and highest patient care areas such as Surgery and Recovery, ICU/CCU, Delivery, Nursery, as well as certain professional and administrative areas including Education and Training, Fiscal Management, and Data Processing (This zone is located on the second level).

(3) The services zone serving a dual function: as a structural base supporting the inpatient area and transferring this load to grade with the minimum number of columns to eliminate spatial constraints at the lower level areas; and as the location of the major support services such as Dietary, Central Sterile Supply (CSS), as well as all mechanical, and electrical machine rooms (This zone is located on the third level).

(4) The inpatient zone containing all levels of care.

Diagram 3.2-18 illustrates the integration of these zones into an operational framework to show how they relate to various levels in a hypothetical facility configuration. The primary organizing elements which tie these activity zones into an operational health care system are:

(1) Two primary vertical circulation and service nodes which link all activity zones together by providing the service requirements for the various flows and vertical adjacency relationships.

(2) A horizontal time/distance grid which relates all flows and functional activities in each horizontal activity zone.

(3) Secondary vertical adjacency relationships between invididual functional areas (such as Surgery Clinic-Surgery Suite and OB Clinic-Delivery Suite) and services.

The major nodes contain elevators, stairs for local circulation, vertical service shafts and chases for mechanical ducts, communication conduits as well as the materiel handling system, if included in the BLHC System. Minor nodes contain stairs for local circulation together with a heavier concentration of HVAC, utility, and electrical services.

The most sensitive patient flows and high technology areas are grouped around one primary node which serves: the high intensity medical zones such as the Intensive Care Unit, Coronary Care Unit, Surgery, Recovery Area, and

Nursery; the highest technology areas of the ambulatory zone such as the emergency admitting area; and the nursing units with the heavy and moderate care inpatients. A vertical adjacency (using both primary and several secondary nodes), therefore, links all medically acute areas, even where they are contained and organized in separate activity zones according to their own unique physical and functional elements.

Other elements -- including the least acute inpatient nursing areas, administration offices, ambulatory clinics for general medicine -- are grouped around the second primary node. These areas deal with patient and personnel flows of large volume but least medical urgency. This organization induces a selective use of the transportation nodes as well as a nodal split between the elevators and the option of using stairs.

The next major organization concept deals with horizontal time/distance relationship of similar functional elements located on the various levels and related to the primary nodes. Studies indicate that an organization based on a horizontal time/distance relationship of 1/2 minute walking and approximately 140 feet around each primary node can be used initially to test desired criteria. All physical layouts generated to date are organized on these parameters. They are constantly being tested in the trade off analyses but have proven satisfactory as outer limits for the largest-size BLHC System studied.

The last, and perhaps most significant, organization concept is that each functional physical element should be comprised of sub-elements with relatively predictable change and growth requirements, and that certain rules and "modules" of space planning should be assigned to these sub-elements. Although nursing units can have change capabilities built into them, the "module" of major growth is a new nursing wing which is added in relatively large increments. High technology areas such as operating suites will have change capability built-in, but growth capability will be accommodated by adding one or more operating suite "modules", which contain 2 OR suites and a recovery area.

The design logic will allow this addition in a way that will minimize effects on patient, personnel, materiel, and data flows. The degree of unpredictability of these changes will depend somewhat on the nature of the sub-element. For example, the radiology area can accommodate major changes in

demand by greater utilization of manpower over longer hours, but beyond a certain limit, growth capability must be implemented. The growth element will clearly be some multiple of the space module required to accommodate an X-ray suite, including patient and staff flow areas and areas for equipment.

Inpatient areas evidence relatively predictable, and less dynamic change. In the ambulatory zone, however, rapid,highly unpredictable change capabilities are necessary in generally smaller and less readily definable forms. The design logic will organize those elements requiring the most flexibility to allow multiple patient entry to a grouping of similar medical treatment areas. It will organize the waiting and flow characteristics of the ambulatory patients into, and between, these areas and provide open-ended expansion into outside areas to accommodate unpredictable demands. These changes and growths can be achieved without disturbing adjacent sub-elements of the ambulatory zone and without altering the logic of the patient entry and flow patterns.

Ambulatory Level (Figure 3.2-19 and 3.2-20)

Ambulatory care is the predominant form of treatment in present and perceivable future BLHC Systems unless the entire character of health care is drastically altered. The traditional view of the hospital Outpatient Department is no longer appropriate for future BLHC Systems. The concept of a highly dynamic ambulatory activity zone presented two major alternatives:

(1) a separate, detached facility; or

(2) the integration of this activity zone into the composite facility.

The alternative of the detached facility offers the opportunity for independent growth and change. The integration alternative offers the advantage of linking all inpatient and outpatient activities into an interrelated framework and maximizing the effective utilization of staff and services in support of both activities.

The integration alternative was judged the best approach, since its design concept offers the advantages of both alternatives. The ambulatory level provides relatively open-ended growth at grade, is integrated into the composite facility, yet is still relatively unconstrained by design decisions for the remainder of the facility. In addition, the patient flows into the system

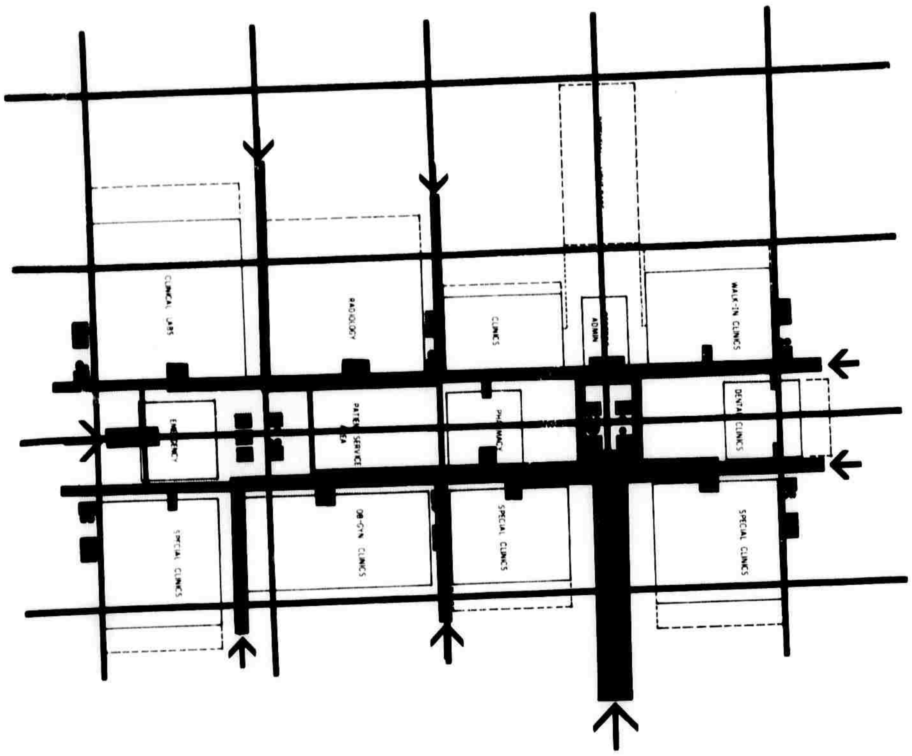


FIGURE 3.2-19. TIME/DISTANCE FRAMEWORK

FIGURE 3.2-20. AMBULATORY LEVEL

and the flow of staff and services within is structured for maximum effectiveness into the functional areas.

The organizational concept of structuring ambulatory patient flow within discrete functional units requires the maximum number of ambulatory clinics at grade (Figure 3.2-19). Based on Study Team data, an estimated 75 percent of the ambulatory patient flow can be scheduled directly into the appropriate clinic. Non-scheduled emergency patients are referred to an emergency control zone (Figure 3.2-19 directly related to the diagnostic facilities and the primary vertical transportation serving the high intensity medical zone (Surgery, ICU, and CCU). The second primary vertical transportation node is related to the ambulatory flow from the inpatient facilities to the clinics and patient service areas. Both primary vertical transportation nodes can accommodate flow of staff and visitors. Secondary transportation nodes (stairs) link the ambulatory level to the medical and professional level. The ability to relate a light care and ambulatory nursing unit to this level is one of the initial or future system options. Fig. 3.2-20 is another representation of the ambulatory level.

Medical and Professional Level (Figure 3.2-22

Intensive medical functions requiring highly specialized technology and environment (Surgery, Delivery, Nursing, Intensive Care, Coronary Care) are concentrated on the second level. Also on this level are diagnostic and therapeutic facilities as well as certain clinics and physicians' offices which primarily respond to inpatient demands.

Most professional staff functions including education are on the first two levels, linked by primary and secondary circulation nodes and framed by the time/distance grid (Figure 3.2-21). The relationship of this level to the other activities contrasts the random movement requirements of the professional staff with their discrete geographic areas. One level up is the cafeteria, one level down, the clinics and diagnostic facilities. The two-level separation of the ambulatory zone from the cafeteria still represents a convenient walk-up distance. To walk up one flight of stairs represents a seven to ten second time requirement. The provision of alternative links directly related to

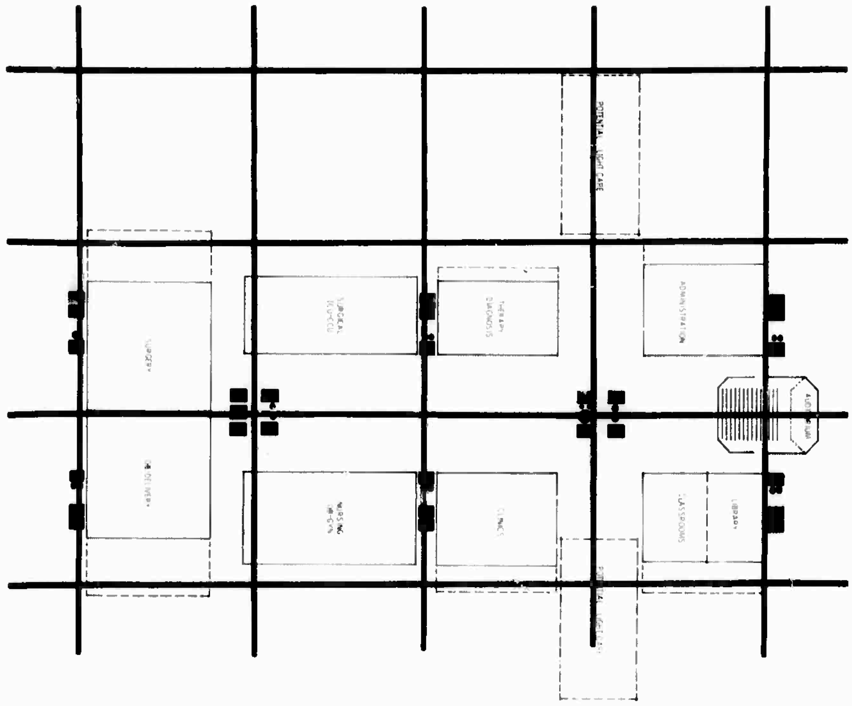


FIGURE 3.2-21. TIME/DISTANCE FRAMEWORK

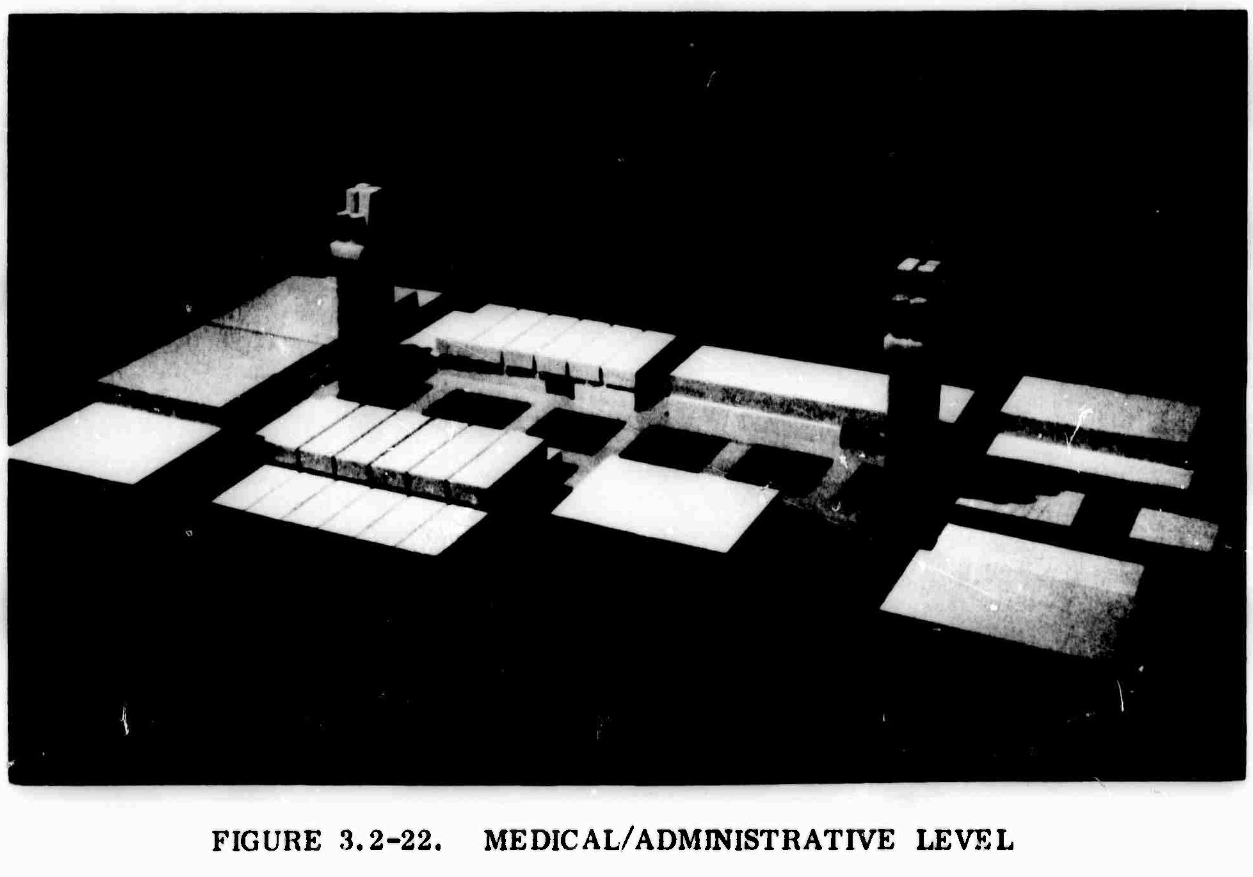


FIGURE 3.2-22. MEDICAL/ADMINISTRATIVE LEVEL

vertical adjacencies ensures that optional movement of the staff resource is well defined, minimizing waiting time for transportation. Fig. 3.2-22 illustrates the second level superimposed over the lower level.

Structural and Mechanical Service Level (Figure 3.2-23)

This level functions primarily as a structural transfer zone, similar to a bridge, which accepts and transfers loads from the inpatient nursing unit elements over wide spans to grade without imposing on lower levels. Since the optimum structural concept for the nursing units may not be suitable for ambulatory care units, the structural bridge acts as a separation and transition point, permitting maximum design freedom and layout flexibility for the levels above and below it.

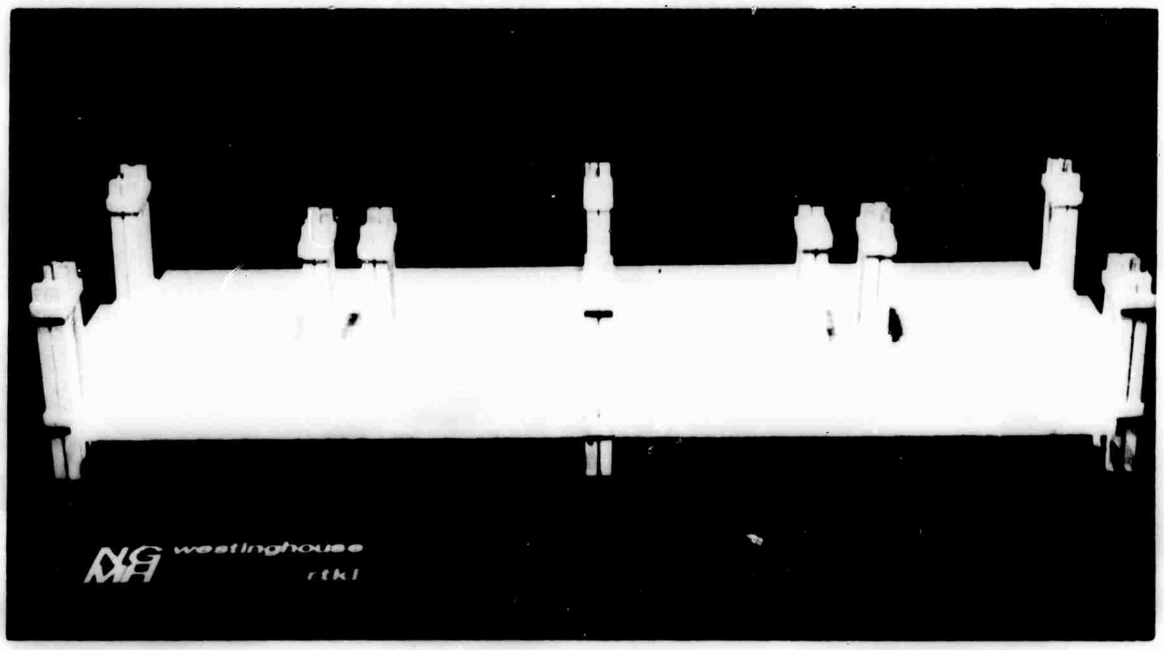


FIGURE 3.2-23 STRUCTURAL TRANSFER ZONE AND VERTICAL NODES

As a second major function, this level contains the mechanical services and distribution channels for the system where they are continuously accessible for maintenance, modification, and upgrading. The mechanical services feed the levels both above and below this zone through primary and secondary vertical distribution shafts. In addition, mechanical services are closest to the medically intensive functions such as Surgery and Intensive Care. Other functions of this level include Dietary, Housekeeping, Warehousing, CSS, and other service elements.

The location of the service functions enhances their proximity to the activity which has the greatest service requirement, the inpatient levels. It also places the majority of the Ward Management staff and ambulatory inpatients within easy reach of the cafeteria, using the stairs in the major and minor nodes which in turn, reduce the load on the primary transportation system.

Inpatient Levels (Figure 3.2-24)

Nursing units of a nominal density of 34 beds are horizontally organized into two or three levels, grouped around the primary and secondary vertical nodes and supported by the structural transfer zone. The time/distance criteria are superimposed so that the horizontal nature of the system will not impose distance penalties (Figure 3.2-24 - black time grid). The secondary nodes facilitate the continuous flow of staff during rounds or between levels. The configuration creates opportunities for a variety of operational and ward management concepts. Medical and nursing activities vary according to patient dependency which requires different staffing and spans of control (Figure 3.2-24 - yellow support management) and the ward administration implies still a different level of organizational control. The inpatient system creates a framework in which the appropriate organization can be applied as determined by patient dependency (Figure 3.2-24 - red medical activity and nursing areas).

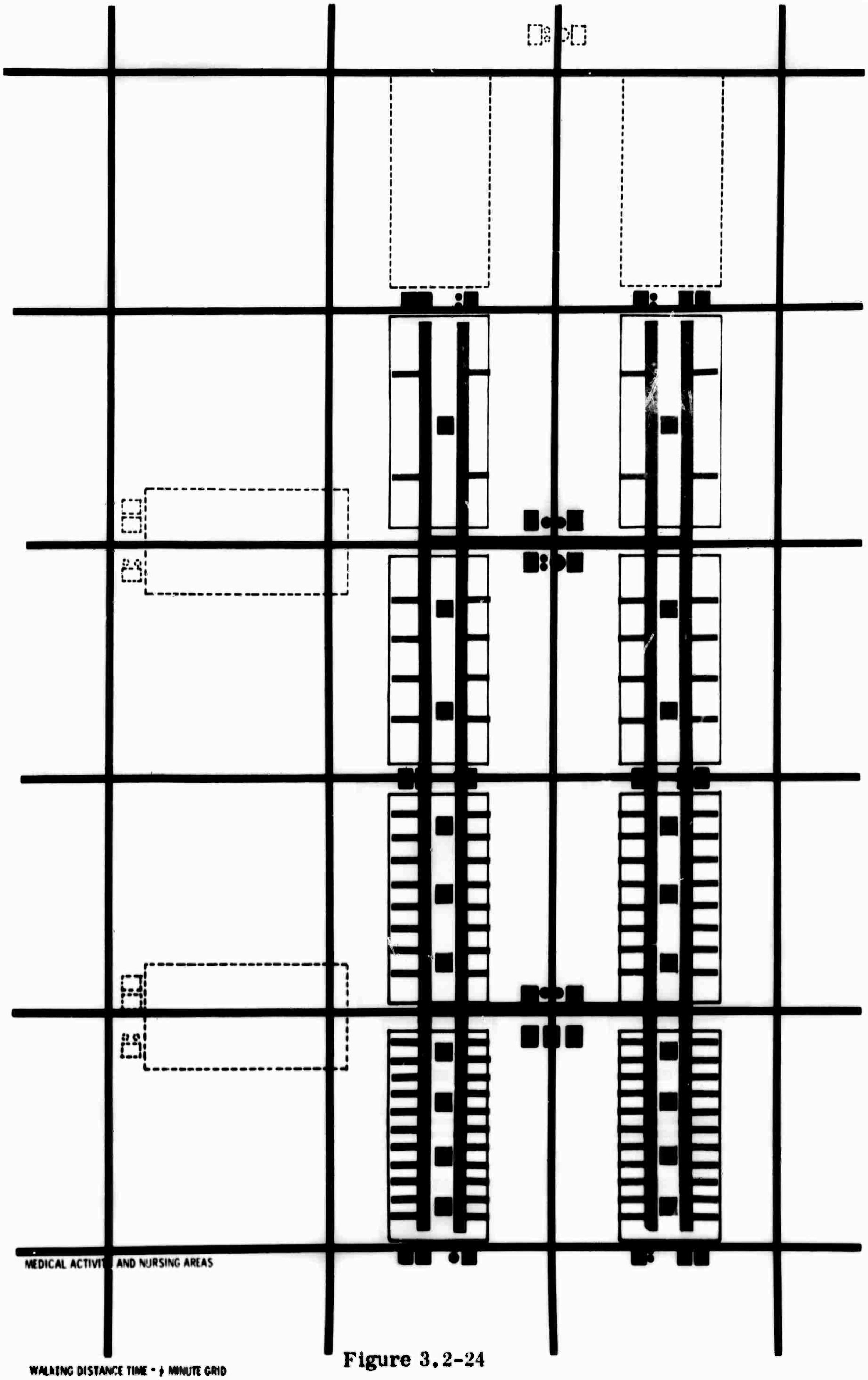

MEDICAL ACTIVITY AND NURSING AREAS
WALKING DISTANCE TIME - ½ MINUTE GRID

Figure 3.2-24

Specifically, concepts of graduated patient care can be applied on an individual nursing unit basis on one level, or throughout all inpatient levels; the traditional inpatient organization by medical specialties and by levels of care can also be utilized. This framework for the analysis of alternatives can be used in the simulation of alternatives as well as in actual test situations for the new generation military hospital.

The system models display operational characteristics of the design concept; it illustrates the relationship of medical intensity to the first primary node, and ambulatory patients to the other primary node. The total system model reflects the interrelationships of all major activities and services, as well as the sequence of care as the patient progresses through the system. (Figure 3.2-25)

Configuration Options

Inpatient

The decomposition of the traditional compact health care facility into more discrete elements permits a wide array of initial size and discrete growth options within the 250- to 750-bed range. Initial configuration options are based on two or three inpatient levels with combination adjacent light care units, generally on grade.

The capability to grow is twofold:

(1) by adding inpatient units onto the structural transfer zone;

(2) by adding incremental modules (Figure 3.2-26).

The growth options and final nominal configurations are based on a basic expansion pattern, which utilizes the existing primary nodes. The growth options have been conceived within certain constraints to permit better configuration comparisons. A summary of the constraints, or system rules reflecting actual conditions which may be found follows:

(1) The number of beds in each new nursing unit remains 34. It not only simplifies the numerical illustration of the system's capability, but also correlates with Medical Health Care Review Team's recommendation.

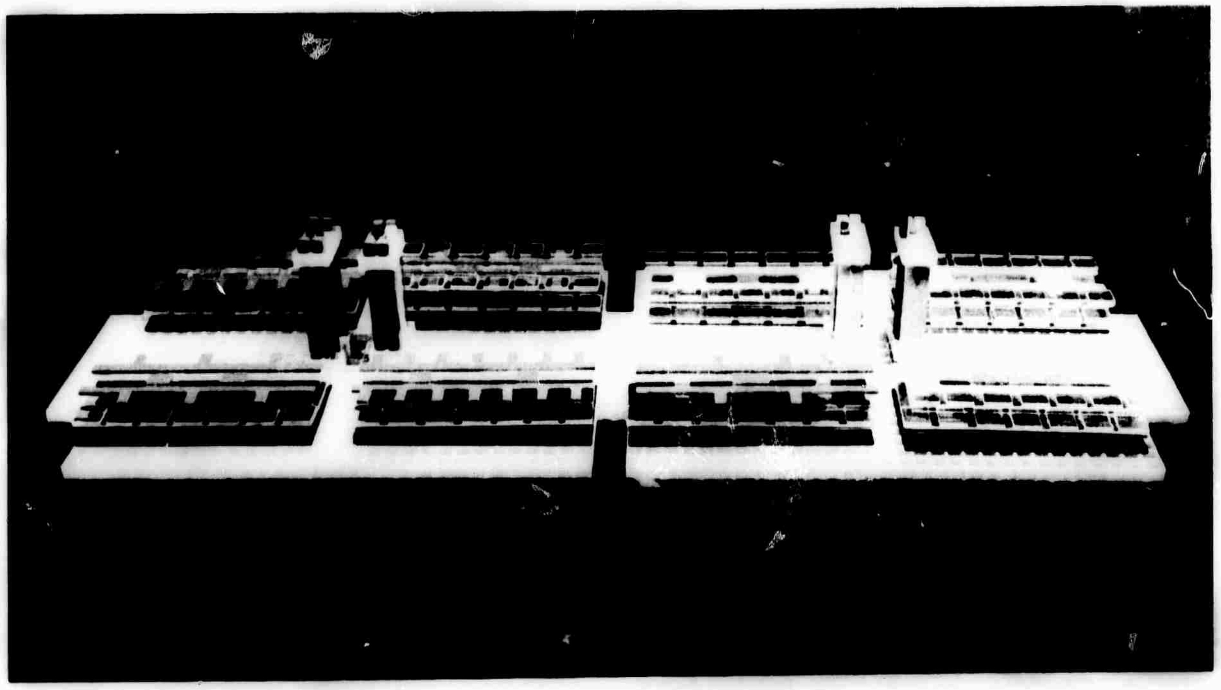
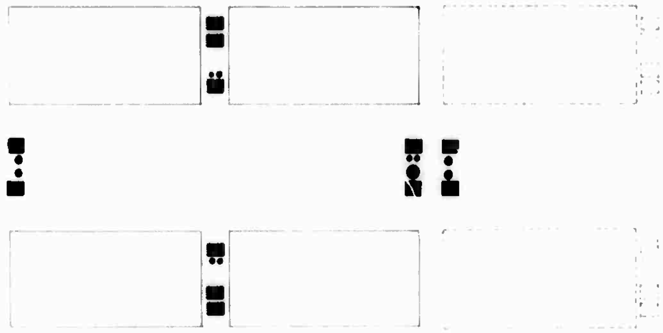
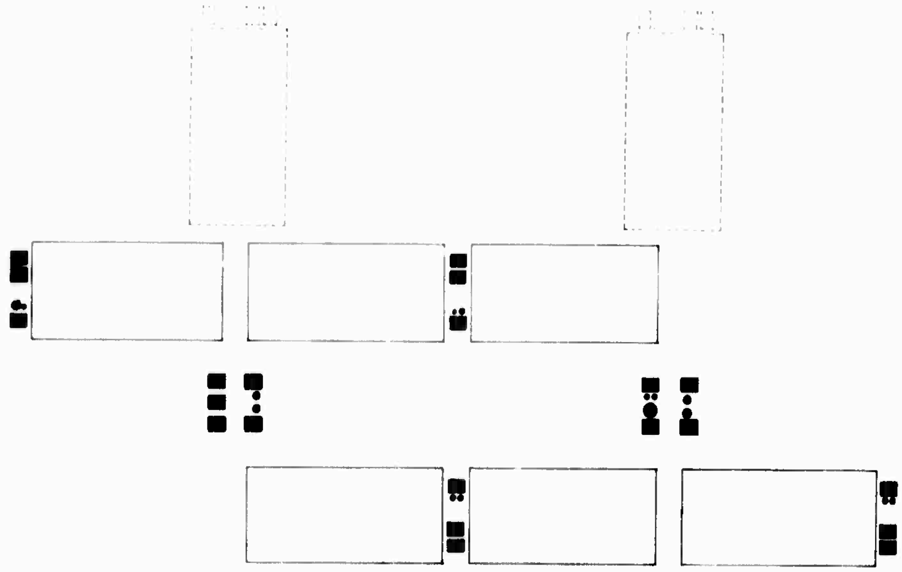


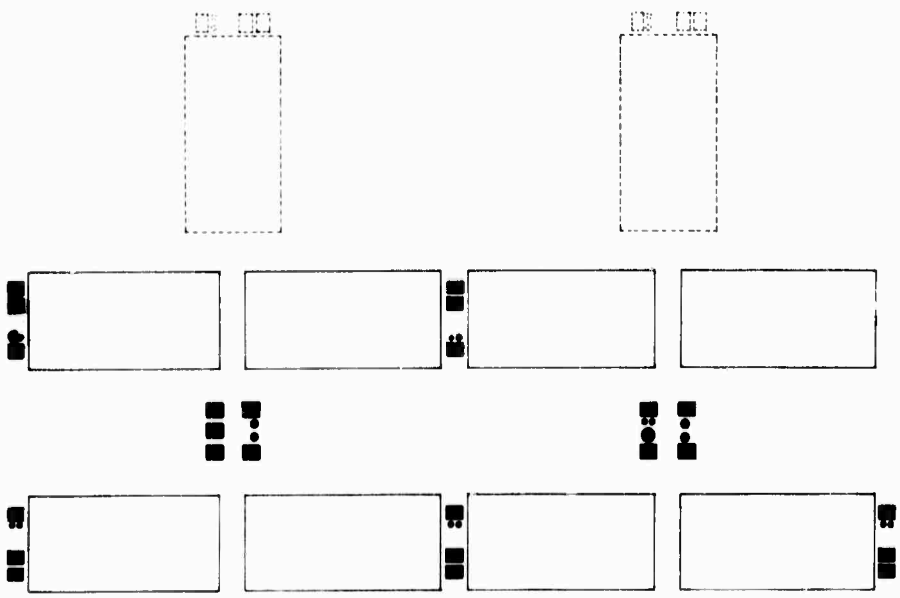
FIGURE 3.2-25. "NEW GENERATION" MILITARY HOSPITAL TOTAL SYSTEMS MODEL



250-BED BASE CONFIGURATION - GROWTH OPTION



VARIABLE ENTRY OPTION



500-BED BASE CONFIGURATION, 2 LEVEL GROWTH OPTION
750-BED BASE CONFIGURATION, 3 LEVEL GROWTH OPTION

FIGURE 3.2-26 SYSTEM DESIGN ALTERNATIVES

(2) Vertical growth is not considered desirable. After an initial configuration is in place, addition of new levels is precluded, except over the structural transfer zone.

(3) Lateral growth can occur in increments of one or two additional inpatient units, provided space is reserved for this contingency on the ambulatory level. From a system operation point of view this type of growth is least desirable; it also constrains development of the ambulatory level.

(4) The choice of initial configuration determines the limits of the final or ultimate configuration. Figures 3.2-27, 3.2-28, and 3.2-29 illustrate the 250-bed, 500-bed, 750-bed initial configuration. The capability of these systems to grow is a function of the choice between two or three inpatient levels, and the initial size of the structural transfer zone. With no constraint on the initial configuration, the two-level system can grow to 840 nominal beds and the three-level system can grow to 1100 beds.

Ambulatory Zone

The ambulatory level can grow to assume any configuration required to match the health care demand in this area and this growth can be largely independent of the inpatient area. Diagnostic support services, also have open-ended growth capability.

IMPROVEMENT ANALYSIS

The general design concept which has been developed does not represent a fixed facility. The various illustrations and the design model are used as tools to illustrate the performance requirements for any BLHCS over its life cycle within a uniform system of organization. The organization is supported by the data base and the performance requirements based on the characterization of the BLHC System. The design model is:

(1) A tool which defines the criteria for improved BLHC Systems;

(2) A methodology which can be used to test various construction

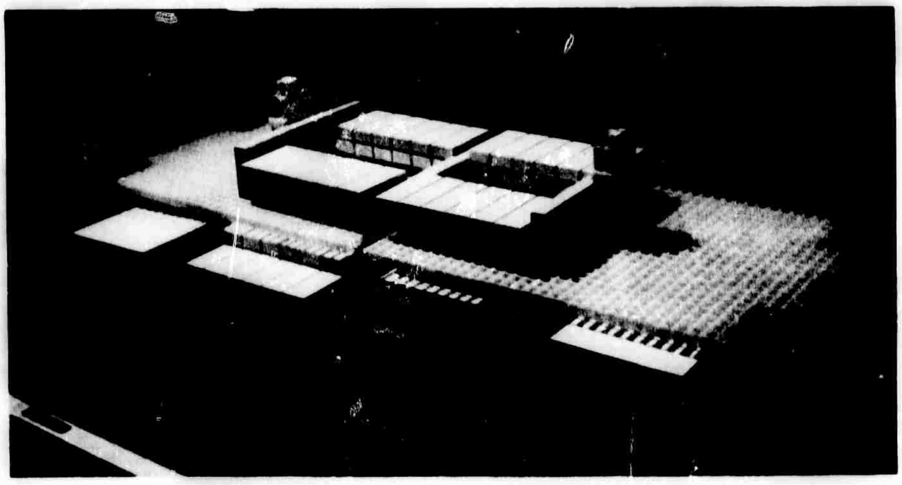


FIGURE 3.2-27. 250 BED CONFIGURATION

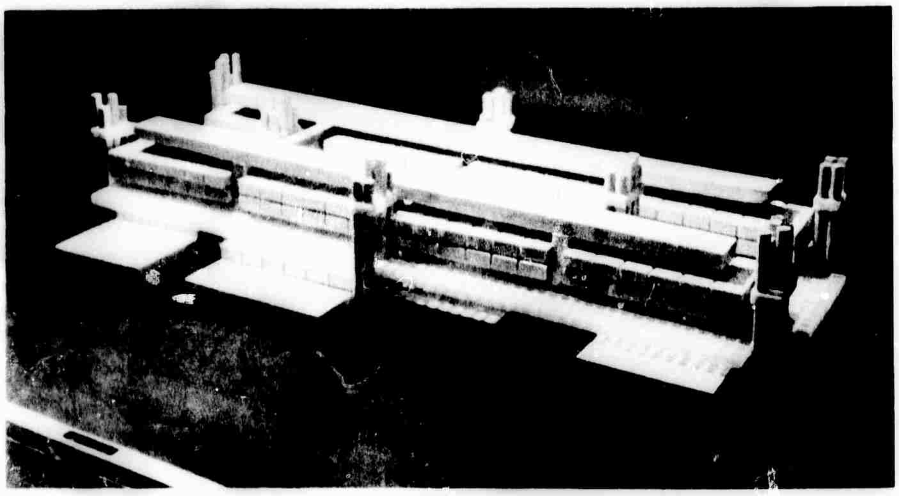


FIGURE 3.2-28. 500 BED CONFIGURATION

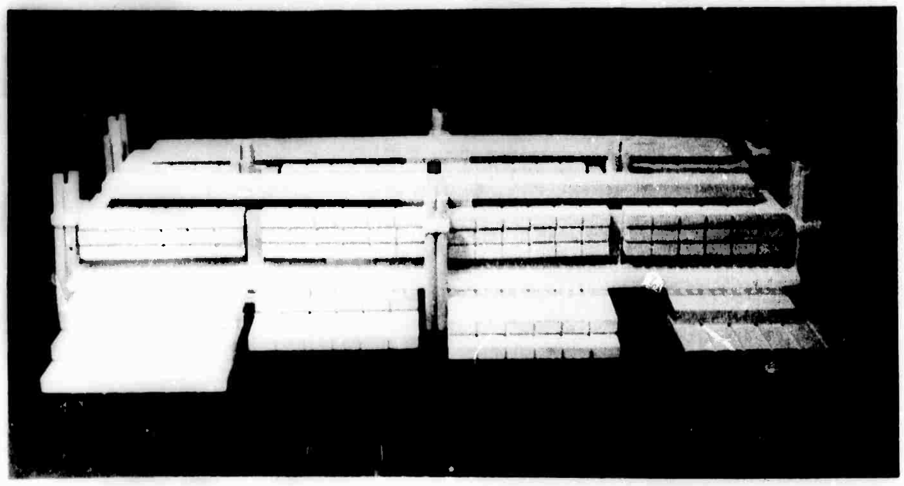


FIGURE 3.2-29. 750 BED CONFIGURATION

technologies and cost variables within the stated planning and design guidelines;

(3) A concept for a new building type.

The comprehensive nature of Base Level Health Care suggests that a homogeneous hospital type which anticipates only the initial demands for health care is not adequate. The facility concept, must be redefined in terms of a system of environments responsive to variety in patient care demands, care intensity, and processing and supported by variable technology and services.

A System of Health Care Environments

Many non-homogenous elements must be integrated into an operational system based upon precise analysis of the various functional interfaces and a definition of the appropriate physical and environmental characteristics of each element. These elements include:

(1) Inpatient units with uniform environment (climate, aseptic), personal convenience elements, medical and professional support.

(2) High technology support areas with medically intensive functions (Surgery, Intensive Care, Cardiac Care, and Delivery and Nursery areas).

(3) High volume personnel processing areas containing ambulatory clinic functions with a moderate demand for space and environment but a high flow capability, relying on administrative and medical support functions such as Medical Records, Pharmacy, Radiology, and Clinical Laboratories.

(4) Supporting service areas containing the system's administrative and administrative support functions such as Dietary, Supplies, Warehousing, Housekeeping, and Mechanical Services.

These elements correspond to change and growth over the system's life cycle, at the lowest total cost.

Capable of Variable Construction Technology

Since BLHC Systems are typically conceived as homogeneous building types, uniform construction technology is usually carried throughout the structure. For example, short-span, poured-in-place, reinforced concrete technology applicable for the upper stories which are usually nursing units may be imposed on ground level areas where such technology is a major constraining factor. The choice of technology is generally the architect's who may not be aware of the long term needs of the facility.

New programming criteria, more closely related to the concept of a non-homogeneous facility, should be established. At least four major non-homogeneous elements of the facility have previously been identified. Criteria which can readily be translated into sub-system hardware, building components, and construction technology have been developed to permit various potential solutions to be analyzed for each element. Consequently, an array of construction options can be maintained until the final construction bids are generated; this will offer great flexibility in adapting to least cost, local practices, and available compatible manufactured items.

Initial construction criteria based on both non-homogeneous elements and the design logic, will substantially affect the manner in which facilities are designed, built, altered, and expanded. Such criteria are based on a greater appreciation of the initial, change, and growth capabilities required of the system.

Capable of Variable Construction Costs

Current planning procedures designed to meet initial capability result in aggregated space allocations, expressed in square feet, for individual hospital areas. An estimated construction cost per square foot, predicated on a fixed time, size, and past experience, and modified by regional factors is applied to this aggregation. This regional factor which is reviewed and updated regularly, is applied to all elements uniformly.

If the total facility is designed and constructed using a non-homogeneous concept illustrated by the design logic, widely varying construction cost levels will result for each major facility element. Highest costs will accrue to highly specialized medical care areas with their concentrations of high technology, such as operating suites, delivery suites, recovery and intensive care areas, nursing areas, and the nursery. Moderate costs will be associated with nursing units generally designed to cope with moderate and light inpatient care and low costs with the high volume ambulatory treatment areas.

Through performance criteria relating to change and growth, a different construction technology and building component selection will be applied to each area. The highest cost area has a very permanent spatial organization; most of the internal walls, for example, can be built of solid masonry combined with long span heavy construction and elaborate mechanical, electrical, and plumbing sub-systems. This area will not undergo major internal change over its life cycle and will grow by addition of major units such as additional operating suites.

The moderate cost area has a less permanent spatial organization with more attention given to effecting change. The internal walls may be built of steel studs and gypsum board instead of masonry, using relatively short span, light-weight "motel" style construction with less elaborate electrical, mechanical, and plumbing sub-systems.

The least costly area is designed for extremely rapid and frequent change and large scale growth over its life cycle. In this area less certainty of prediction will be possible for each major sub-element. Indeed, the only certainty is change. The primary effort, therefore, will be to organize the major flow patterns of people and materiel through the sub-elements while still providing for change and growth. This will be accomplished by coupling long span construction with easily demountable partitions for internal space divisions and sub-systems organized to permit convenient change. Such flexibility is possible because this area generally requires the lowest level of

technology. Although sub-systems such as Clinical Laboratories and Radiology require special treatment, their growth is predictable based on modules of activity.

Costs can be estimated not only for each major element but for each major sub-element as well. Major sub-system elements which are central and common to several areas (elevators, materiel handling systems, major electrical entry and distribution systems up to the secondary transformers, major mechanical equipment such as chillers and cooling towers) can be estimated separately and their costs apportioned according to their usage by, or impact on, the various facility elements.

Cost forecasting is comprised of two major elements:

(1) Initial or acquisition costs;

(2) Long term or life cycle costs.

To permit more accurate appraisals of projected first costs a new approach to developing improved cost guidelines and criteria is being generated as part of the design logic. This approach emphasizes computer-based appraisal techniques; it is keyed more to discrete building elements than the present conventional aggregation of square foot allowances and uniform cost allocation per square foot. In addition, allowance should be made for cost escalations encountered between planning and construction contract awards.

To match demand with costs over a 20- to 25-year life cycle, a planning tool based on dynamic optimization has been developed. It is being refined and its limitations defined by depicting certain costs and performance characteristics of older-style hospitals. By combining the population demand model, the dynamic optimization process, and a detailed characterization of construction and operating costs for the proposed new hospital concepts, an optimal strategy can be generated for any specific BLHC System. Any or all of the major parameters can be varied to develop life cycle costs, including raising the rate of construction cost escalation, raising the rates paid to hospital personnel, dramatically and suddenly changing demand to simulate a

major mission change, imposing lengthy delays between need recognition and fulfillment, or imposing very tight budget constraints. Using computer analysis, the results can be used to examine various decision options, such as physical configurations and their impact on life cycle cost. This planning tool will be a valuable aid to decision-making when planning and constructing specific BLHC Systems.

Variable Technology and Cost Matrix

A specific tool has been developed to illustrate the capabilities of the design model to accept technology and cost variables within the discrete activity zones. Table 3.2-4 displays the technology options as functions of unit costs for each activity zone of the BLHC System. The summary matrix aggregates the cost results and a least-cost path can be defined against the performance objectives of the BLHC System. The detailed analysis for the major activity zones and individual functional elements was prepared by McKee-Berger Mansueto (See Appendix 3.2-1).

SENSITIVITY ANALYSIS

The design concept provides an organization and configuration which achieve the sensitivity objectives stated for the design. The specific sensitivity analysis which will demonstrate this is the hypothetical Base "X" which is a test example with assumed operational and mission variables over its life cycle.

However, the design concept remains sensitive to several specific factors:

(1) Geographic location

(2) Land availability

(3) Site conditions and topography

(4) Constraints of existing facility elements.

For any given geographic location, the most appropriate technological application to the design concept may not be available. This may result in slightly modified capability or somewhat higher initial cost for that location.

The availability of land is also critical to the design concept. The horizontal configuration requires a larger site than the conventional health care facilities, and the future growth capability is contingent on the availability of

TABLE 3.2-4

NGMH T_0

COSTS BY LEVEL, AREA, AND BUILDING SYSTEM

(DOLLARS/SF)

SUMMARY / BUILDING SYSTEM	AREA: AMBULATORY	MED.-ADMIN.	SERVICE	INPATIENT	CONSTANT	TOTAL COSTS
1.0 Foundations	-	-	-	-	3.00	3.00*
2.0 Super Structure						
2.1 Steel frame, concrete fireproofing and slabs (US Steel Scheme)	7.87	8.43	13.49	7.87	-	9.15*
2.2 Steel frame, concrete fireproofing and slabs (Bethlehem Scheme A)	9.30	10.05	23.27	7.87	-	11.85
2.3 Steel frame, concrete fireproofing, and slabs (Bethlehem Scheme B)	8.70	9.75	21.87	7.87	-	11.35
2.4 Steel frame, concrete fireproofing, and slabs (Bethlehem Scheme C)	6.27	6.40	10.10	7.87	-	7.65
2.5 Reinforced concrete slabs, beams, columns	8.43	9.12	23.61	6.33	-	10.97
2.6 Metal deck & concrete slab (Inpatient level only)	-	-	-	7.87	-	-
2.7 Precast concrete (Inpatient level only)	-	-	-	8.12	-	-

TABLE 3.2-4 - (Cont'd)

NGMH T_0

COSTS BY LEVEL, AREA, AND BUILDING SYSTEM

(DOLLARS/SF)

SUMMARY / BUILDING SYSTEM	AREA AMBULATORY	MED. - ADMIN.	SERVICE	INPATIENT	CONSTANT	TOTAL COSTS
3.0 Exterior Wall						
3.1 Face brick, masonry back-up (Cavity)	2.95	4.75	1.95	2.40	-	2.89
3.2 Face brick, masonry back-up (solid)	3.26	5.07	2.15	2.62	-	3.15*
3.3 Stucco facing, blockwall	2.73	4.31	1.83	2.20	-	2.67
3.4 Precast concrete panels	3.84	5.96	2.57	3.10	-	3.72
3.5 Glass & metal panels	3.95	6.14	2.65	3.19	-	3.83
4.0 Interior Finish						
4.1 Austere	11.08	18.24	8.10	9.15	-	11.15
4.2 Average	13.04	20.28	8.60	10.48	-	12.60*
4.3 Generous	15.50	23.35	9.00	13.10	-	14.80
5.0 Roof system	-	-	-	-	.85	.85*
6.0 Casework	1.90	3.00	.70	2.30	-	2.00*

TABLE 3.2-4- (Cont'd)

NGMH T_0

COSTS BY LEVEL, AREA, AND BUILDING SYSTEM

(DOLLARS/SF)

SUMMARY / BUILDING SYSTEM (AREA)	AMBULATORY	MED.-ADMIN.	SERVICE	INPATIENT	CONSTANT	TOTAL COSTS
7.0 Plumbing	3.15	4.43	2.10	4.36	-	3.60*
8.0 Heating, ventilating and air conditioning						
8.1 All air/induction	9.74	10.65	4.40	4.35	1.86**	7.42
8.2 All air/fan coil	9.65	10.55	4.36	4.31	1.84**	7.35
8.3 All air/incremental	9.19	10.05	4.15	4.10	1.75**	7.00*
9.0 Electrical	4.86	6.05	8.36	6.11	.98**	6.55*
10.0 Elevators	-	-	-	-	1.10	1.10*

* Costs of Test Configuration

** Mechanical and Electrical Equipment

land to accommodate the building growth as well as the increased parking requirements.

Site conditions and topography must be evaluated on an individual basis for each application of the Design Concept. Varying site conditions may or may not have advantages in terms of costs. The long spans of the structural transfer zone require fewer footings and in difficult soil conditions would require fewer fills. In turn, the larger foundation slab area may be more costly under other circumstances.

The location of existing health care facilities on the selected site may be a constraint in the siting and orientation of the Design Concept relative to the most desirable flow patterns. The degree of sensitivity of the design to these factors must be evaluated in each specific case. None of these factors except land availability is critical to the realization of the Design Concept's capabilities.

CONCLUSIONS AND RECOMMENDATIONS

A very critical element in the basic needs of the BLHC System is the time lag between the perception of need for a BLHC facility and occupancy of the completed building. This lag is translated into both direct cost and changed demands and requirements for operations. Since the facility is the most fixed resource in the System, its inability to respond to change becomes an operational constraint. Also, emphasis on least first cost ultimately results in higher life-cycle costs.

Three major needs or problems have been identified in the present process of facilities design.

(1) Anticipate the dynamics of demand on a BLHC facility over the life-cycle.

(2) Forecast operational requirements of the BLHC facility over its life-cycle, i.e., utilization, patient mix, staffing, and health care trends.

(3) Translate requirements into appropriate design and implementation specifications, including specific statements of the operational and performance objectives for the BLHC facility over its life cycle.

These needs are answered with specific study results for immediate implementation in the 1972 test facility and short-term R&D to support the 1972 design, as well as long-term R&D programs applicable to 1975-80. The Systems Design concept illustrates the performance requirements for any BLHC System (250 to 750 bed) over its life cycle based on the outputs of the Demand Model. It does not represent a fixed building with a master plan for expansion, rather the concept is responsive to the varying health care demands: initial health care, change, and growth.

- Initial Health Care

  Within the overall organizational logic based on the detailed characterization of the BLHC System, a wide range of initial configuration options can accommodate inpatient, ambulatory, and ancillary support functions. These requirements can be varied independently as a result of policy directives and sliding scale criteria.

- Change

  The Design Concept allows for change and modifications in the various activity zones most susceptible to change. This concept includes the structural transfer zone which creates large unobstructed space and the pattern of mechanical services which permits modification of specific areas without disturbing other areas.

- Growth

  Within the overall organization logic, any initial configuration can grow within the rules and constraints of that logic. This growth capability is based on stated objectives for the various sized BLHC Systems. Further, the growth of functional

elements (radiology, clinical laboratories, ambulatory clinics, nursing units) can be achieved individually without compromising the operational capability of the System. The design elements which create this capability are the structural transfer zone, the pattern of horizontal and vertical mechanical servicing, and the open-ended configuration of the individual functional areas.

To forecast operational characteristics of the BLHC facilities over their life cycle, the Design Concept accommodates: changing utilization policies, changing patient mix, changing staffing patterns, and changing health care trends and technology.

- Changing utilization policy

  The arrangement of the inpatient areas permits increasingly higher utilization in all levels of care by the swing capability between the various care levels and the progression of the patient through the health care system. The incorporation of light care units within the total inpatient system permits these units to be progressively upgraded to higher levels of care during the System's life cycle.
- Changing staffing pattern

  The inpatient areas are not designed for a specific staffing pattern but accommodate variable patterns according to levels of patient dependency. Differential spans of control can be used by nursing and by administrative and ward management.
- Changing health care trends and technology

  The degrees of flexibility planned for the various activity zones, reflect the relative rates of change in these health care activities. The ambulatory care zone is the most dynamic and is a key element. The accessibility of both horizontal and vertical mechanical services permits the upgrading of

these services to accommodate new environmental and service requirements in the various functional areas.

The Design Concept translates the requirements into appropriate design and implementation specifications.

- The Design Concept can be implemented within the current policies and criteria and is less sensitive to the time lags inherent in the process.
- Without destroying the overall organizational logic the reduced sensitivity allows the Design Concept to respond to changing requirements caused by the time lag.
- The individual cost elements can be manipulated based on various construction and technology alternatives for individual functional areas. The capabilities of the configuration for future growth and change may result in higher initial cost; however, the concept of life-cycle cost/benefits will result in savings for the total cost of the facility.
- The constant organizational logic for the BLHC System designs reduces the sensitivity of the facility to the problems of discontinuity in the planning and design process.
- The Design Concept illustrates the operational characteristics and performance requirements for BLHC Systems. Each individual design configuration can be evaluated against these characteristics. The sub-elements such as radiology, surgery, and the ambulatory clinics, similarly illustrate individual requirements of these elements within the overall organizational logic.

The System Design Concepts are responsive to the needs and problems found in the present BLHC facilities. They will:

- Respond to the operational objectives of the BLHC System.

- Meet life-cycle performance requirements of a BLHC System while maintaining the System's organization logic.
- Reduce sensitivity of the Design Concept to the uncontrolled time lags inherent in the planning process.

The Design Concept is fully responsive to the health care recommendations which have been defined by the Medical Health Care Team for the "New Generation" BLHC System. Microstudies of sub-systems further identify specific responses to the recommendations.

The evaluation of the cost characteristics of the Design Concept indicates that the capabilities of the design are not purchased at initial cost penalty. Trade-offs hypothesized between the individual activity zones of the Design Concept have produced an overall facility which is competitive with conventionally designed health care facilities. The Design Concept qualifies as a major improvement alternative. The degree of benefit is based on how the concept is applied to a specific BLHC System. Westinghouse recommends that this concept, as defined and illustrated in the design model, become the framework and basis for the "New Generation" Military Hospital design.

SHORT TERM R&D

1. Proceed with Phase II, considering it a short-term R&D effort in itself. Part of the Phase II R&D yield will be definitions of new criteria and requirements for incorporating the various technological options and improvement alternatives into design specifications for NGMH facilities.

LONG TERM R&D

1. A long term R&D effort should be undertaken to determine the feasibility of market aggregation for DoD health care facilities for application of industralized building components. The objectives are reduced first cost and reduced design and construction time.

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3.3 Operations Analyses

INTRODUCTION

The Westinghouse Study Team concentrated on a systems analysis of those improvement areas which affect the flow and control of patients, staff, communications and materiel between the major functional subsystems of the BLHC System, as well as those management functions which affect the operations within each subsystem.

The ten functional areas analyzed in this study are called "functional subsystems," although these areas often relate to management options which cross many functional lines. For each functional subsystem the broad requirements of the RFQ were used as a guideline in devising improvement alternatives for more effective and efficient Base Level Health Care Systems without lowering the quality of care delivered.

Most study team members involved in the improvement analyses also participated in the data gathering and data inventory process at the primary and secondary study hospitals and have first hand knowledge of the System and the "real life" environment into which proposed alternatives would be introduced. Team members not part of the original data gathering process were chosen for expertise in a specific function area.

Characterization of the Present System

The most obvious characteristic of the BLHC System was the variation observed between specific facilities -- even within the same service -- in terms of costs and resources for the performance of equivalent tasks in the delivery of health care or support services. In many cases this variation could be attributed to lack of uniform accounting procedures. However, analysis of labor and materials cost, and use data revealed many substantial differences derived by detailed analysis of the nine primary and secondary

BLHC Systems and confirmed by data collected across the services. Many of these differences in costs could be related to two basic issues:

1. whether the facility was operating above the capacity for which it was originally designed
2. whether the patient mix was more or less acute in nature.

Part of the fundamental variations between facilities was related to management ability, and part to how well the physical facilities provided for gross operating capacity. Staffing patterns were generally related to total days of inpatient stay at a facility rather than to the patient mix. Little evidence of management controls were found which could identify the resources expended for a given patient's progression through the System, including his post hospitalization treatments. Such resource utilization profiles are needed to develop consistent management tools which permit comparison of performances to levels of care both within and between BLHC Systems.

The second most obvious System characteristic was its extreme dependence on labor at all skill levels. This does not mean that labor can or should be eliminated; nevertheless, a system so labor dependent is vulnerable in several ways:

1. Cost of labor may escalate due to factors beyond the management control.
2. Labor may become scarce or even unavailable.
3. Quality of labor may decline and impair system operation.

Both military and civilian health care systems throughout the country exhibit this labor dependence and have suffered all three of these effects. High turnover within the military due to normal duty rotation does not permit the individual to gain sufficient familiarity with a job or with co-workers, and often contributes to a lower level of skill and teamwork than is desirable. This occurs at all levels.

Currently, the escalation rate of labor cost is less in the military than in the civilian sector; however, the supply of labor is finite and should be treated as a scarce resource. If the disparity between labor costs in the military and civilian sectors continues to increase, the military health care system will be increasingly faced with labor shortages or labor of a lower caliber.

One result of this labor dependence is the limitation it places on the system's ability to grow and change. This sensitivity extends beyond the capability of adding more beds or changing the general level of care in existing beds, since changes in the workload of a labor dependent system generally require disproportionate additions to the labor force at all levels including supervising roles.

Effective management of a complex system depends on the accuracy, availability, and relevance of the data for the most significant elements in the system. Only when armed with the right facts can management make the right decisions. The managers of a BLHC System face the challenge of efficiently applying specific resources of facility, staff, and supplies to a complex set of health care demands. This is based on a sophisticated knowledge of the resources being applied to each patient at each step of his care, and the ability to adjust nearly constant facilities and staff to the variations in the resources required to perform these functions.

In the BLHC Systems, the most significant example of data management is the handling of individual medical records which provide the key to many decisions relating to overall facility management. Most data, however, were handwritten, hand carried between functional elements, and laboriously hand filed and retrieved. Even the best system, dependent on manual transmission, storage, and retrieval of data, will never be capable of performing these functions adequately, since the very nature of the data demands will generate more paper work which will ultimately decrease the effectiveness of the system. However, the BLHC Systems

do not have the best manual methods for data flow; their operational needs in this area have not been used as an integral element in the design process. As a result, as the system reaches and exceeds the capacity for which it was designed, it deteriorates at an accelerating rate.

The labor dependence combined with the formidable data flow within the system inevitably produces inefficiencies. Some general examples of this problem are:

- the amount of laboratory tests rerun because of lost records
- the higher number of days in light care as the system becomes larger due to less efficient discharge procedures
- the number of return visits required due to the extended time required to complete tests, record the results, and return them to physicians
- the amount of food wasted daily because dietary needs are not adequately forecast
- the high cost of inventory carried
- the loss of physicians' and nurses' time to purely administrative demands or housekeeping decisions

The design of facilities can be blamed for some of these inefficiencies but by no means all of them. In many cases management policies or traditional procedures interfere with the most effective use of the scarcest resources. As a result, the highest cost labor within the BLHC System is often used for a function which could be performed by less skilled and less costly personnel at no loss of quality in the patient care process.

TECHNICAL APPROACH

Problem Identification

From the system characterization the major problems relating to BLHCS operations can be listed.

- The reporting and measurement methods used in the current Systems are largely historical accounting devices not intended to be decomposed and related to patient care dynamics. Many current measures of performance tend to reward low cost of operation _per se_ without regard to the patient mix and system throughput.
- The system is labor dependent with adverse effects on the flow of data and materiel, the effectiveness of resource utilization, and efficiency.
- System operations tend to be performed manually because lowest first costs are usually most compatible with manual performance.

These problems are so broad that they apply to almost every area of operations in the system. To focus on the most productive areas, the team established a list of the most likely improvement areas drawing upon knowledge of civilian health care systems. After the initial data gathering effort, this list was refined to include ten major areas for analyses:

(1.) Communications and Data Management
(2.) Materiel Handling
(3.) Dietary
(4.) Clinical Laboratories
(5.) Dental
(6.) Outpatient Departments
(7.) Ward Management
(8.) Education and Training
(9.) Pharmacy
(10.) Radiology

Objectives

The following objectives were established for analysis of each of the ten problem areas:

(1) The recommended improvement alternative should show a prospective simple or life cycle cost reduction over the present method of operations or, have a high probability of simple or life cycle retrospective cost savings in comparison with the present methods of operation.

(2) Cost savings should be effected by introducing technology or management concepts which reduce the system's labor intensity.

(3) Where cost savings cannot be readily estimated either retrospectively or prospectively, the improvement alternative must be directed at either reducing the system's dependency on labor or improving the efficiency and effectiveness of a higher echelon of labor. These can be accomplished by developing procedures which will produce the same end result using a lower echelon of labor.

(4) All recommended alternatives must be aimed at reducing the system's sensitivity to change and growth.

(5) All hardware-based improvement alternatives must be fully operational by 1972; the "New Generation" Military Hospital should be a prototype which will not prohibit the facility from performing its mission if the prototype fails to work as expected.

(6) All recommended alternatives must be able to perform as claimed without lowering the quality of health care.

(7) All recommended alternatives must minimize factors which might inhibit the rapid introduction of 1975 improvements.

(8) All recommended alternatives should be implementable within the policies of procurement and operations of the Federal Government and the DoD, or with reasonable modifications to these procedures.

Measures of Effectiveness

For the analyses of the ten major areas, the computed workload of each area served as the objective measure of effectiveness. Workload was calculated as a function of inpatient beds or outpatient visits, or both, using data collected at the study BLHCS. Cost analyses for each alternative under the computer workload determined the ordering of the alternatives.

In the Systems Application (Base "X"), workloads for each area were computed as a function of time, using the Westinghouse Demand Model. These time-varying workloads were then cost analyzed to arrive at the recommended alternative for Base "X".

Subjective qualitative measures of effectiveness were considered as well as the evaluations by the Medical Health Care Review Team, who considered the effect of alternatives on quality of patient care, convenience, and acceptability by staff and patients. Their professional judgments were weighed as part of the cost/benefit analysis.

Synthesis of Alternatives

The first step in the process of synthesizing alternatives for each study was to use the data inventory to portray the major characteristics of the present methods of operation. Although the methods vary for each study, several common characteristics exist:

- The initial facility costs and costs for increments of growth.
- The components of labor cost, including man hours, base pay, and fringe benefits.
- The costs of materials associated with the specific operation.

To show the impact of size on a facility, these items were determined for an array of different-sized facilities.

State-of-the-art documents were examined to select potential, available improvement alternatives. Using consulting manufacturers' data, user data and, in some cases, estimates, component parts of the alternatives were compared with parts of the present system. Some alternatives were less complex to evaluate than others, and some specific alternatives were represented by only one concept or procedure. In some cases, such as Surgicenter, the Team suggested improvement alternatives where no specific problem had previously been identified.

Analysis of Alternatives

Three basic types of analyses were used where appropriate:

1. Life Cycle Cost Savings Analysis
2. Breakeven Cost Analysis
3. Benefit Analysis

1. In the life cycle cost savings analysis, each improvement alternative was characterized and analyzed to allow investment in facilities, operating costs of labor, and operating costs of materiels to be generated against some common output base (for example, labor cost to prepare a single average meal). These data were then inserted into a formula to determine the "present value" total life cycle cost of each alternative for each scale of output. Each evaluation used the following common considerations:

- the period of years representing the "life" of the operation;
- annual inflation rate in the cost of labor to operate the system;
- annual inflation rate in the cost of materiel used in the process;
- annual inflation rate in the cost of materiel used to generate the system output.

To perform sensitivity analyses simply and quickly, each of these factors was used as a parameter variable in the present value equation below.

$$PV = I_o + \sum_{n=0} \frac{1}{(1+i)^n} \left[(1+r_1)^n C_1 + (1+r_2)^n C_2 + (1+r_3)^n C_3\right] - \frac{S}{(1+i)^N}$$

where PV = present value

I_o = initial investment in dollars

$\frac{1}{(1+i)^n}$ = present value of 1 dollar received in N years discounted at an interest rate of (i). For this study a constant cost of money factor of 10% was used.

r_1 = annual rate of escalation in the cost of labor attributed to the alternative under study. For all analyses a rate of 4% was used.

r_2 = annual rate of escalation in the cost of supplies contained in the output. For all analyses a rate of 0% was used.

r_3 = annual rate of escalation in the cost of materials used to generate the system output. For all analyses a rate of 0% was used.

C_1 = annual cost of labor to produce a given level of output for each alternative.

C_2 = annual cost of materiel contained in this output.

C_3 = annual cost of materiel used to generate this output.

S = salvage value.

This format was developed to use a computer-based, evaluation program previously generated by Westinghouse for similar types of analyses.

(2.) The breakeven cost analysis calculated allowable cost to determine the potential saving in using automated over manual alternatives. The allowable cost was, in effect, the amount which could be allocated for automating to achieve a breakeven point, or level at which overall cost to the system is no greater than is the existing system. This analysis required a detailed statement of the system's performance requirements, an evaluation

of the capability of each alternative to reduce system costs, and the upper and lower bounds of obtainable cost savings. Then, each of the more promising alternatives was evaluated by whether the alternative would reduce labor dependency, system sensitivity to change and growth, and sensitivity to technological obsolescence.

(3.) These cost benefit analyses related to those areas of operations where quantification of expected savings or increased efficiency was not possible, however, expert judgment indicated that these items will contribute to a more efficient and effective BLHC System within the framework of objectives.

Some of the recommendations generated by the Medical Review Team are examples of these alternatives.

Sensitivity Analyses

Sensitivity analyses were performed on every functional sub-system, to a greater or lesser degree, depending on the nature of the analysis and the importance of the alternative. These analyses tested:

(1) Whether the alternatives were characterized in a comparable manner on performance and cost;

(2) The validity of the alternative against variations in the major elements of the analysis as a result of the impact of economic factors such as rates of inflation and costs of money;

(3) The impact of changes in the character and size of the operation.

The first of these tests was extremely important because it allowed the Study Team to use "hard" and "soft" data from a wide variety of sources. Wherever doubts existed about data being used, an analysis could immediately be generated on the degree of allowable error.

The second test was designed to determine the impact of basic economic pressures over which the BLHC System management has little or no control. The two basic issues were: (1) whether the alternative rankings change due to changes in any of these areas and, if so, to what degree

and (2) whether the alternative being recommended shows greater or lesser sensitivity to changes in the economy than the present system. The best alternative was the one least affected by issues not controllable from within the system and which exhibit a lower cost increase than the present alternative.

The third test was designed to establish the sensitivity of any alternative to change and growth compared to the present method. An alternative favorable on all other counts but extremely sensitive to change and growth was not adequate for the BLHC System.

This section describes the general processes used in analyzing the ten functional areas. Because each of the areas is unique in some respects, each individual improvement analysis and the resulting recommendations are discussed in detail in the following sections.

COMMUNICATIONS AND DATA MANAGEMENT

The communication and data management function coordinates the many hospital activities to facilitate effective delivery of health care. Although discussed separately in the State-of-the-Art volume, communications and data management were analyzed as one, since all total information networks which fulfill the system's data management needs also incorporate the more advanced communications alternatives.

As the function which binds and coordinates other functions, communications and data management provides patient and resource management information necessary for the delivery of health care. The importance of data exchange, interaction, and manipulation within and between the many base level health Care Systems cannot be overemphasized since all management and health care decisions depend, to some degree, on the availability and accuracy of data.

Technical Approach

Our technical approach to studying and analyzing communications and data management consisted of four phases: (1) documentation of present methods; (2) data summary; (3) activity identification; and (4) user needs definition.

Documentation was obtained from three DoD hospitals, using computer programs to characterize the present communications methods. The following reports (detailed in the Data Inventory volume) formed a basis for analysis:

(1.) Reference listings of all data collection -- Computer Report No. 11

(2.) Statistical averages -- Computer Reports Nos. 41 and 42

(3.) Use of Forms -- Computer Report No. 32

(4.) Reports on Resources -- Computer Reports Nos. 51 and 52

(5.) Problem, Resource, Suggestion, and Trend Analysis -- Computer Reports Nos. 62-65

(6.) Information Volume by Communication Mode -- Computer Report No. 81

(7.) Information Volume by Source -- Computer Report No. 82

(8.) Information Volume by Destination -- Computer Report No. 83

(9.) Information Volume by Urgency -- Computer Report No. 84

(10.) Information Volume by Purpose -- Computer Report No. 86

(11.) Work Sampling Observation Analysis

All data collected were categorized by 18 hospital functions:

(1.) Ward Management

(2.) Supply

(3.) Dietary

(4.) Pharmacy

(5.) Administration

(6.) Operating Room

(7.) Dispensaries

(8.) Clinics

(9.) EKG Lab

(10.) Emergency Room

(11.) Maintenance

(12.) Radiology

(13.) Housekeeping

(14.) Medical Records

(15.) Clinical Laboratory

(16.) Physical Therapy

(17.) Dental

(18.) Personnel

Data Summary. The collected communications data was summarized and a set of communications profiles characterizing the existing system were prepared for incoming and outgoing documents by purpose and type. (See

Data Inventory volume.) These profiles identify those functions which are the major communications users. Initial conclusions are:

(1.) Of the 18 functional areas observed, six (Ward Management, Clinics, Registrar, Clinical Laboratory, Pharmacy, and Radiology) account for approximately 80 percent of the total communications traffic.

(2.) Only 10 percent of the total communications volume travels via existing communication equipment -- 90 percent are hand carried (a large portion by patients). Figure 3.3-1 gives a breakdown of hand-carried records by area.

(3.) Over 90 percent of these hand-carried documents could be transmitted by an efficient automated communication network.

File categories thought necessary for BLHC operation did not vary directly with hospital size. There are 353 file categories at Beaufort (280 beds), 217 at Andrews (350 beds), and 304 at Fort Dix (1,000 beds). The number of file categories per functional areas as well as file composition within the functional areas varied considerably, except for medical record files, which are almost equal in composition at the three BLHC Systems.

The Andrews AFB files were examined to determine which files could be computerized and to determine annual file maintenance costs. Figure 3.3-2 shows a file analyses for the six largest functions representing 93 percent by volume of all the files at Andrews. Figure 3.3-3 gives a breakdown of one of these functions (Ward Management) showing the specific files which could be automated. This shows that over 135.5 file maintenance man hours per month and 64.6 file access man hours per month can be saved by automation.

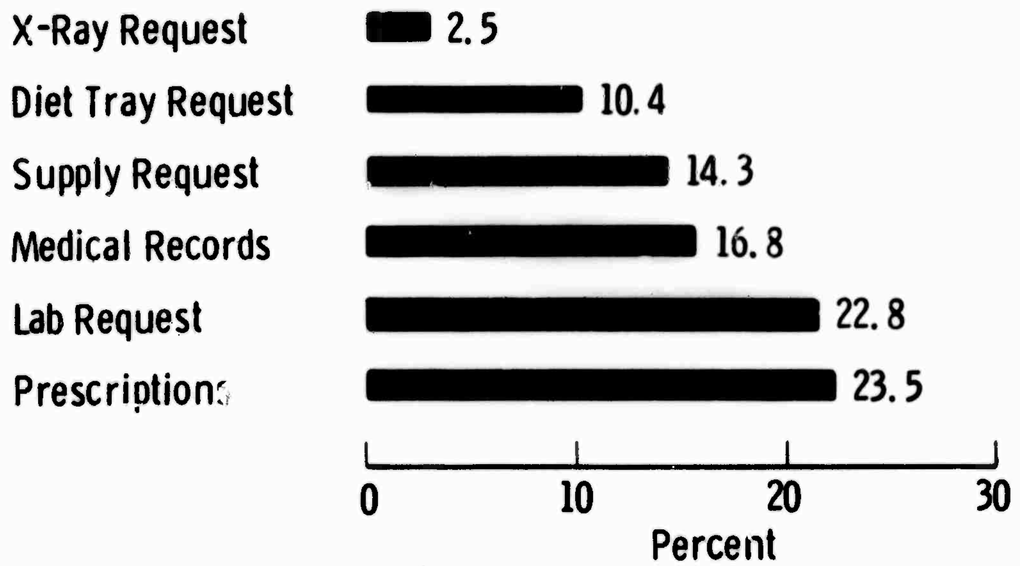


FIGURE 3.3-1 PERCENTAGE BREAKDOWN OF VOLUME OF HAND-CARRIED RECORDS (90.3 % of total communications load).

File Function	Cumulative File Size	% Total	Annual File Maintenance Cost
Radiology	192,399	33%	$ 33,645.08
Registrar (Med Rec)	176,106	30%	245,129.28
Clinical Lab.	124,700	21%	7,940.64
Ward Management	30,014	5%	10,588.68
Pharmacy	12,370	2%	2,661.12
Outpatient Clinics	12,011	2%	57,263.76
			$357,228.56

The above functions account for approximately 93% by volume of all files at Andrews Air Force Base.

FIGURE 3.3-2 FILE ANALYSIS FOR ANDREWS AIR FORCE BASE

Input Output No.	File Name	Man Hours/Month for Maintenance	Man Hours/Month for File Access
341140	Weekly O.R. Schedule	5.3	2.0
341141	Surgery Register	18.7	2.8
344121	Inpatient Clinical Rec.	100.0	35.0
344211	OB Previous Inpatient Records	0.6	1.3
344230	Inpatient Location	0.6	10.5
344231	OB Previous Patient Locator	0.3	0.3
344260	Narcotic Log & Chief File	9.0	12.6
344261	Supply Requisition File	0.7	0.2
	TOTAL	135.2	64.7

FIGURE 3.3-3 AUTOMATABLE WARD MANAGEMENT FILES - ANDREWS AFB

Activity Definition. Activities within the six major functions were then identified. Ward management activities, for example, include patient care, administrative and clerical duties, housekeeping, training new employees, traveling between hospital functions, and non-productive time, none of which are automated.

Communications links between particular tasks (both intra- and inter-functional) are detailed in the Data Inventory volume.

Definition of User Needs. Based on knowledge of the BLHC System operation gained during data inventory and work sampling, a comprehensive set of user needs in communications and data management was developed. Each improvement alternative was examined for its ability to function within this framework and to reduce manual effort.

Improvement Alternatives

Improvement alternatives described in the State-of-the-Art volume are grouped into three categories:

I. Commonly known and used, such as messenger, U.S. Government mail, private mail, public address, motion pictures, and the conventional telephone.

II. Medium advanced equipment commonly incorporated into all-encompassing total information networks. Such equipment includes teletypes, intercoms, paging systems, telewriters and facsimile equipment, closed circuit television, and microfilm.

III. Total information networks, usually computer based, and with varying abilities to meet the communications and data management needs of the BLHC System.

Groups I and II were not analyzed in detail; selected components were evaluated to determine the feasibility of combining them with alternatives from Group III. Eight of the improvement alternatives are described below.

(1.) <u>National Data Communication Corporation Real Time Electronic Access Communication for Hospitals (REACH)</u> is a totally integrated communication and data management network. The user has direct access to computerized data base via a specifically designed cathode ray tube (CRT) with a special 20-key keyboard, or a typewriter keyboard. These keys plus a special user identification card allow the physician, nurse, and/or technician to select standard phrases which can be stored in the patient's record. Hard copy is simultaneously printed at remote locations when necessary. Using the keys plus standard keyboards, pre-admitting, scheduling of ancillary services, patient accounting, or narcotic medical data can be entered. Most medical or administrative data can be handled by program statements that appear on the CRT screen. Nurses' notes, doctors' orders, patient histories, and narrative progress notes can be typed as a patient record or phrases can be selected by the physician or nurse from a structured program text. Any staff member can be allowed to use restricted segments of the patient record.

REACH software is considered proprietary by the National Data Communication Corporation and is provided to the hospital (including a complete operations and maintenance staff) as a utility. Limited batch data processing is performed in the user hospital on a Honeywell 516 Computer; additional computer processing is done at the regional center at Dallas, Texas, using a Honeywell 1200 Computer. REACH includes computer output microfilm (COM) for major administrative reports and completed medical records of discharged patients.

(2.) The IBM Corporation's Medical Information System Package (MISP) is the most widely used hospital information network. MISP is an executive control program able to switch messages from remote terminals on a real time basis. SHAS (Shared Hospital Accounting System) is commonly employed. In the basic hardware configuration for the MISP/SHAS package, data entry and output are primarily from 1092-1093 programmed keyboards and the 1052 typewriter, not a CRT screen. The operator can visually select data by pressing the appropriate button on a 128-key keyboard. Keyboards for data input are faster but less flexible than video input.

MISP/SHAS prints reminders and test results, stores patient data, handles inquiries, switches messages, and produces administrative reports; it significantly reduces administrative paperwork and provides the basis for a total hospital information network. Video display applications in the admissions office are currently under development at several locations.

(3.) The Burroughs Corporation "On-line Medi Data System" is a time-shared concept serving up to 1500 beds in multiple locations from a central site. The user can directly interface with the central files using a cathode ray tube linked directly to the central processor. Hard copy is produced by R033 teletypes controlled by small computers (the B300) located at the remote hospital facility. The Burroughs concept maintains the handwritten doctor's

orders and patient history. A specially trained terminal operator (replacing the ward clerk) uses specific codes to enter data at the CRT terminal. Expanded orders are immediately printed for verification at various ancillary services.

Department work schedules, assignments, statistics, test results, patient bills, and administrative reports are available through the information retrieval program in each department's CRT terminal or teletype. The results of ancillary services work (for instance, test results) are transmitted to the central computer and redirected to the appropriate nursing station where they are printed and manually inserted into the patient's chart.

(4.) Sanders Associates Communication and Data Management System (formerly Clini-Call Hospital Information System) consists of three major software packages: business accounting, medical data management, and laboratory data management. These three packages are integrated to form the standard version of the "Hospital Data Management System."

Data input is via a light pen, used to select standard phrases or words which appear on the CRT screen at each terminal. The computer maintains files, sorts information, and summarizes and routes specific communications throughout a health care system. Computer checks are made on drug and other ancillary service requests against stored lists of normal limits.

The business and accounting package provides the routine administrative services such as accounting, payroll, inventory control, and general ledgers.

The Medical Data Management Package handles physician orders, test results, and dietary requests. User identification cards are required when orders or specific information should be available only to authorized personnel.

The Laboratory Data Management Package uses the common data base of the total network for maximum efficiency. It frees the technician

of clerical duties, such as recording or verifying test results and writing logs, by creating patient worksheet files, specimen collection lists, specimen labels, and printout of all test results.

(5.) The Lockheed Space and Missile Company Medical Information System (MIS-1) is a centralized medical data service center that provides an inter-reactive video terminal with a light sensing pen and typewriter keyboard. MIS-1 combines the time sharing concept with rapid access capability and enables physicians to review data at the CRT terminal. It operates similarly to the REACH, Medi-Data, and Sanders alternatives described above. MIS-1, however, offers local printers (A.B. Dick ink-jet) at each nursing station which prepare numerous routine reports for patient and administrative management, such as discharges, 24 hour and shift summaries, admitting and medication records, patient status reports, transfer and admitting notices, new medical orders, and requisitions.

(6.) The ITT Standard Real Time Patient Information System stores patient status data in a computerized file and displays the data periodically or continuously. Data is fed into the computer via a remote keyboard, is stored, and can be instantly retrieved and displayed at any remote CRT location. Graphs, laboratory reports, test results, and other pertinent patient data are transmitted among intensive care units, coronary care units, operating laboratories, head physicians office, the X-Ray consultation room, and other selected locations. Since this alternative is highly patient-oriented, it cannot route messages like standard orders or capture charges for services performed.

Currently in use at the Karolinska Institute in Sweden, this alternative can expand to a total information network. Long range plans are to integrate it with the National Medical Information System under development at the Danyard Hospital in Stockholm County.

(7.) The Medelco Total Hospital Information System (THIS) is used primarily as a data input and transmission device, not for data retrieval. Card readers feed data from coded prepunched cards into the main central processor, which then sorts the data and instantly transmits it to all preselected print terminal locations throughout the BLHC System. Charges are generated each day and are provided in a daily batch output compatible with most computer systems.

(8.) Control Data Corporation, Honeywell and Univac offer computerized accounting hardware and software systems, all of which have basically the same package with some differences in procedures and type of output. The major difference is their integration into a time-shared total information system.

User Needs

All total information networks and their software are effective in at least one hospital function. Each was considered for its medical acceptability, potential for 1975 implementation, contribution to improved patient care, and abilities to reduce cost. Figures 3.3-4 through 3.3-7 indicate the range of user needs that would be accommodated in a complete information network for the BLHC System. The cost figures and square footages are based on actual figures from the three BLHC Systems studied. Figure 3.3-8 illustrates the flexibility of the improvement alternatives studies with respect to incorporating the defined user needs.

Conclusions

1. Of the 18 functional areas observed, six (Ward Management, Clinics, Registrar, Clinical Laboratory, Pharmacy, and Radiology) account for approximately 80 percent of the total communications traffic.
2. Only 10 percent of the total communications volume travels via existing communication equipment -- 90 percent are hand carried.
3. Over 90 percent of these hand carried documents could be transmitted by an efficient automated communication network.
4. A significant amount of directly measurable cost can be saved in the six key functional areas by displacing manual activities with computer based systems. The amount of savings is sufficient to justify introduction

FIGURE 3.3-4

BASE LEVEL HEALTH CARE HOSPITAL INFORMATION SYSTEM
ADMINISTRATIVE OPERATION
USER TASKS

Computer Operation	Clinics	Registrar	Nursing	Laboratory	Pharmacy	Radiology
1. Scheduling	Visits	Record Retrieval	Ancillary Support Services	Special Procedures	IV Fluid Therapy	Special Procedures & Routine Inpatient
2. Charges	Civilian Visits	MSA Accounts	Civilian Inpatient			
3. Workload Acctg.	Clinic Procedures	Summary Reporting	Special Procedures	Laboratory Procedures	Prescriptions Issued	Procedures Performed
4. Report of visits	Clinic Visits	Summary Reports				
5. Resource Management	$\boxed{\text{Projection of Staffing Pattern Demands}}$*	$\boxed{\text{Predict Epidemiological Data}}$	Predict Staffing and Facility Requirements	$\boxed{\text{Predict Demands for Laboratory Test}}$	Inventory Control	$\boxed{\text{Predict Staffing and Resource Requirements}}$
6. Patient Status	Identification of Revisits	Daily A&D Report	Bed Availability	Inpatient/ Outpatient Utilization	Inpatient/ Outpatient Utilization	Inpatient/ Outpatient Utilization
7. OJT Progress Report	Scheduled Report for Corpsmen	Scheduled Report for Corpsmen	Scheduled Report for Corpsmen	Scheduled Report for Corpsmen	Scheduled Report for Corpsmen	Scheduled Report for Corpsmen
8. Payroll	Civilian Staff	Civilian Staff	Civilian Staff	Civilian Staff	Civilian Staff	Civilian Staff
9. General Acct.	General Expenditure	Gen. Expenditure Patient & Billing	General Expenditure	General Expenditure	General Expenditure	General Expenditure
10. Medical Boards	Physical Examination	$\boxed{\text{Board Action}}$				

* Boxed tasks require long-term research efforts.

FIGURE 3.3-5

MEDICAL INFORMATION NETWORK

USER TASKS

Computer Operation	Clinics	Registrar	Nursing	Laboratory	Pharmacy	Radiology
1. Source Data Collection	Physician Input of Original Data	Clerical Input of Admission Data	Professional Staff Input of Patient Data	Automated Instrumentation	Technician Input of Data	Technician and Physician Input of Data
2. Communication of Physician Orders	Lab. Orders, X-rays, Ordered Prescriptions, Ancillary Svcs., Future Scheduling.	Medical Records, Medical Boards, Clinical Chart	Lab. Order, X-ray Order, Prescriptions, Ancillary Svcs., Future Schedule	Lab. Requests	Medications	Radiographs
3. Summary Reporting	Functional Performance	RPG Capability	Shift Nursing Report, Patient Care Report	Quality Control Inventory	Inventory	Procedures Report Inventory
4. Result Reporting	All Test Results, X-ray Reports	Results Storage	All Test Results, X-ray Reports	All Test Reports		Film Readings
5. Requisitioning of Supplies and Services	Satisfying Unscheduled Demands, Expendable Supplies, Special Services	Expendable Supplies	Expendables, Central Sterile, Ancillary Svcs.	Expendables, Scheduling of Blood Drawing	Resupply Expendables	Resupply, Expendables
6. Transfer of Orders	Broadcasting Physician Orders to Multiple Sources	Generation of Orders from Medical Board	Broadcasting Physician Orders	Special Diet Request	Unissued Orders to Central Supply	Special Diet Request
7. Library Reference	$\boxed{\text{Diagnostic Assistance, Adverse Drug Reaction}}$ *	Generation of Medical Indices	Bed Status	$\boxed{\text{Diagnostic Assistance}}$	Formulary	$\boxed{\text{Diagnostic Assistance}}$

* Boxed tasks require long-term research efforts.

FIGURE 3.3-6

STORAGE AND RETRIEVAL

USER TASKS

Computer Operation	Clinics	Registrar	Nursing	Laboratory	Pharmacy	X-Ray
Record Storage	Outpatient Record	Inpatient Record Medical Boards	Clinical Chart	Lab. Request Lab. Logs	Prescription Drug Files	Radiographs, Radiology Requests, Reports, and Cross Reference
Record Retrieval	Outpatient Rec. Inpatient Rec. Clinical Chart	Inpatient Rec. Summary Statistics Med. Boards	Clinical Charts, Inpatient Rec., Outpatient Record	Lab. Logs Lab. Req.	Inventory Reports	Radiographs, Inpatient Records, Outpatient Records
File Purging	Outpatient Record	Inpatient Record	Clinical Chart	Laboratory Procedures	Prescription Issued	Radiology Report
Record Transfer	Outpatient Record	Inpatient Record	Clinical Chart	Laboratory Request		Radiological Requests
Record Summarization	Outpatient Record	Inpatient Record	Clinical Chart	Laboratory Procedure	Prescription Issued	Radiology Reports
Chronological Listing	Patient Visits Consultations	Medical Board	Narcotic Issue Surgical Procedure OB Deliveries	Specimen Processed	Prepack Medication	Radiograph Accession Consultation
Indexing	Outpatient Record	Admissions	Inpatient Record	Patient No.	Patient No.	Accession Number, Patient Number

FIGURE 3.3-7

PHYSIOLOGICAL DATA ACQUISITION
USER TASKS

Computer Operation	Clinics	Registrar	Nursing	Laboratory	Pharmacy	Radiology
1. Patient Monitoring	Vital Signs Cardiac Output*		Fluid Balance Circulatory Variables Blood Gases	Entry of Test Results		
2. Parameter Measurement	EEG ECG Pulmonary Function		Lab. Results Monitoring Blood Volume O_2 Uptake	Entry of Test Results Electrolytes	Impact of IV Fluid Therapy	Automated Analysis by Radioisotopes
3. Physiological Trend Analysis	Stress Testing	Trend Summary	ICU CCU Surgery	A/D Instrument Input	Adverse Drug Reaction	
4. Telemetry of Physiological Data	ECG Blood Pressure		Cardiac Output Temp.	Test Results from Shared Laboratory		
5. Multiphasic Diagnostic Screen	Patient History Differential Diagnosis	Abnormal Findings Report		Multi-Testing		Automated Screening of Radiographs

*Boxed tasks require long-term research efforts.

		Adminis-trative Operation	Medical Information Network	Storage and Retrieval	Physiological Data Acquisition
1.	National Data Communications REACH	+	+	+	!
2.	IBM Corporation MISP-SHAS	+	+	-	!
3.	Lockheed MIS-1	+	+	-	!
4.	Sanders Associates CLINI-CALL	-	+	!	-
5.	Control Data Corp. HIS	+	-	-	-
6.	Medelco Inc. THIS	-	+	!	o
7.	Honeywell Inc. HCSS	+	!	!	!
8.	Burroughs Corp. BHAS-MEDI Data Proj.	+	+	-	!
9.	Univac	+	!	!	o
10.	ITT-Standard Radio	!	!	-	+

\+ - Capable of performing 80 percent of user tasks
\- - Capable of performing only 20-40 percent of user tasks
! - Capable of performing user task with moderate system revision
o - Incapable of performing any user task without major system revision.

FIGURE 3.3-8 STATE-OF-THE-ART
HOSPITAL INFORMATION SYSTEMS

of computer based systems.

(5.) In addition to quantifiable costs there are other considerable benefits, such as reduced record loss and more rapid record completion.

(6.) Most information networks can fulfill today's administrative requirements; a few can satisfy medical information network requirements, and only one, REACH, can fulfill the storage and retrieval needs.

(7.) Computers, currently, are not economical mass storage devices, especially for medical records storage. Adequate data storage and retrieval capabilities, however, are available which interface with other current hospital information methods, that do not currently use microfilm as a storage medium. (See Appendix 3.3-1).

(8.) Only one alternative, ITT-Standard Radio, best fulfills the physiological data acquisition needs for the NGMH; research programs must be defined and implemented to satisfy most requirements.

(9.) A computerized BLHC information system can be cost justified.

(10.) The more comprehensive automated information system cannot be justified unless the subjective benefits can be realized.

(11.) Only the least expensive and rudimentary information system can be cost justified in BLHCS below 400 beds.

(12.) Distribution is a minor cost factor.

Recommendations

While it is impossible to implement a completely computerized BLHCS information network at present because of current hardware and software limitations, the capability for a total system should still be built in. Westinghouse recommends, therefore, that consideration be given to initial installation of a central dedicated processor with time-sharing capability. Although this processor cannot be cost justified initially, it will provide the capability for incorporating a complete information network as software and hardware developments are forthcoming.

Any system adopted should have the following essential features:

- A central processor dedicated to the NGMH system;

- Time-sharing by functions within the system;
- Computer software will use a commonly shared data base with a natural language interface;
- Basic input/output media should be a CRT, or a television format device with limited hard copy capabilities.

We also recommend that DoD sponsor a short term research and development program to investigate the use of microfilm for the production, storage, and retrieval of data and its applicability to BLHC Systems. (See Appendix 3.3-1)

Evaluation Criteria

Each alternative was evaluated for its abilities to:

(1.) Reduce patient stay;

(2.) Reduce lost records in order to eliminate repeat laboratory and radiology procedures;

(3.) Improve physician and auxiliary personnel utilization through workload leveling;

(4.) Reduce operating cost through improved inventory control and resource utilization;

(5.) Reduce data collection records by sharing a common data base;

(6.) Meet NGMH user requirements as detailed in Figures 3.3-4 through 3.3-7.

(7.) Eliminate redundancy in recording data;

(8.) Provide rapid availability of data.

Evaluation Assumptions:

(1.) Initial and/or per-month lease costs for hardward and software based on manufacturer's estimates or Westinghouse derived cost;

(2.) Twenty percent added to all direct personnel costs to cover fringe benefits;

(3.) Useful life cycle of 10 years for all hardward and software

(4.) Inflation rate of 6 percent and 4 percent for labor and operating costs, respecitvely;

(5.) Discount rate of 10 percent for money.

Cost/Benefit Analysis

The cost/benefit analysis was conducted in five steps:

(1.) Estimate the personnel costs which each alternative can displace in the six major functions and activities within each function, using work sampling data. Then compute an annual displaceable cost for 250-, 380-, and 750-bed hospitals. Tables 3.3-1 through 3.3-6 estimate annual displaceable cost by function and activity, and totals.

(2.) Estimate cost savings, such as reduced patient stay (assumed average patient stay was reduced by one day), reduced dietary cost (10 percent through computerized menu planning, and improved inventory control and fiscal management (Table 3.3-7).

(3.) Estimate the displaceable floor area in the registrar and file storage areas (Table 3.3-7).

(4.) Compute each alternative's hardward and software rental cost, with added personnel cost when applicable.

(5.) Calculate the life cycle cost for each improvement alternative for the various sized hospitals, using inflation rates of 4 percent and 6 percent on subjective savings (Figures 3.3-8.1 and 3.3-9).

Figures 3.3-8.1 and 3.3-9 compare these life cycle costs with the maximum total displaceable personnel cost for 250-, 500-, and 750-bed hospitals, designated "manual" on the chart.

To use the graphs, locate hospital size (number of beds) on the horizontal axis. A vertical line will intersect the present volume for each alternative for that hospital size. The difference between each alternative's cost and the manual displaceable cost is the amount a given-sized hospital can afford to pay for a specific alternative.

For example, a 500-bed hospital's total life cycle cost for REACH is about $2,000,000; total displaceable personnel cost is about $9,500,000. Therefore, a 500-bed hospital will save $7,500,000 for REACH over its life cycle.

Work Sampling Activity	Maximum Displaceable Cost	Personnel Activities Displaceable by Improvement Alternative					Estimated Displaceable Annual Cost by Facility ($)		
		Lockheed	REACH	Bur-	San-C	IBM	250	380	750
Administrative [illegible]									
[illegible]	[illegible]	[illegible]	[illegible]	2.0	1.0	2.0	33,[illegible]	12[illegible],[illegible]02	113,315
[illegible] Recording, Filing [illegible]	[illegible]	[illegible]	[illegible]		2.2	[illegible]	29,[illegible]17	113,170	12[illegible],1[illegible]7
[illegible] of Data Recording, Non-advanced Training	[illegible]	[illegible]	[illegible]	3.0	3.0	4.5	40,38[illegible]	154,323	172,074
d. Giving Teaching Instructions	.3	.1	.2		.1	.1	2,019	7,71[illegible]	8,603
Maintenance Checking Supplies and equipment	[illegible]		[illegible]		.1	.4	3,361	12,860	14,339
Travel Time	1.0	1.0	1.0	.5	.5	.7	6,731	25,[illegible]20	28,679
Totals	17.2	11.0	16.1	5.5	6.9	9.7	115,774	142,391	193,227

TABLE 3.3-1 FUNCTIONAL AREA WARD MANAGEMENT

Work Sampling Activity	Maximum Displaceable Cost	Personnel Activities Displaceable Improvement Alternative					Estimated Displaceable Annual Cost by Facility ($)		
		Lockheed	REACH	Bur-	San-C	IBM	250	380	750
Communications between physicians and laboratory	10.7	10.7	10.7	7.5	10.7	9.5	10,556	65,144	60,074
Sample Identification	3.2	1.6	1.6	1.6	1.6	2.5	3,157	19,572	17,466
Analysis and calculation	21.7						21,409	132,723	121,833
Total	35.6	12.3	12.3	9.1	12.3	12.0	35,122	217,739	199,373

TABLE 3.3-2 FUNCTIONAL AREA CLINICAL LABORATORY

Recording Information	7.1	5.0	6.0	3.5	3.5	2.5	26,050	143,889	101,744
Retrieve, File or handling information	3.1	2.0	2.5	1.5	1.5	1.0	11,374	62,825	44,445
TOTAL	10.2	7.0	8.5	5.0	5.0	3.5	37,424	206,714	146,189

TABLE 3.3-3 FUNCTIONAL AREA OUTPATIENT CLINICS

Work Sampling Activity	% Maximum Displaceable Cost	% Personnel Activities Displaceable by Improvement Alternatives: Lockheed	REACH	Bur-	San-C	IBM	Estimated Displaceable Annual Cost by Facility ($): 250	380	750
Registrar activities	9	4.5	1.5	4.5	1.5	4.5	8,487	25,645	34,251
Clinical records file maintenance and disease indices	10	7.5	10	5	3	3	9,110	28,494	48,057
Outpatient records maintenance	9	7	9	7	2.5	2.5	8,487	25,645	41,251
Accession and disposition activities	[illegible]	[illegible]		3	3	4	2,829	8,448	11,117
Totals	31	22	[illegible]	19.[illegible]	13.0	14.[illegible]	29,8[illegible]	84,[illegible]	117,970

TABLE 3.3-4 FUNCTIONAL AREA: REGISTRAR (MEDICAL RECORDS)

Receipt, reading & numbering of prescriptions	5.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,[illegible]	4,152	4,417
Typing of R_x labels	[illegible]	[illegible]	[illegible]	0.7	0.7	0.7	2,410	4,288	[illegible],063
Administrative recording, checking, filing information	3.[illegible]	1.0	[illegible]	4.[illegible]	1.0	3.[illegible]	1,183	3,677	4,337
Checking and maintaining inventory on wards	2.0		2.0		1.0	2.0	848	2,101	2,478
Totals	11.2	9.7	13.7	11.[illegible]	10.7	13.7	6,019	11,918	17,595

TABLE 3.3-5 FUNCTIONAL AREA: PHARMACY

Work Sampling Activity	% Maximum Displaceable Cost	Personnel Activities Displaceable by Improvement Alternatives: Lockheed	REACH	Bur-	San-C	IBM	Estimated Displaceable Annual Cost by Facility ($): 250	380	750
Reading X-Rays and dictating reports	.5	.1	13	.1	.1	.1	183	1,375	1,259
Unrelated recording, reading or checking data	.1						37	375	252
Administrative recording, checking of information	3.0	1.5	2.5	1.5	2.5	1.5	1,096	8,218	7,553
Retrieving Information	1.9	1.0	1.9	1.0		.5	691	5,221	4,784
Totals	5.5	2.6	17.4	2.6	2.6	2.1	2,010	15,222	13,848

TABLE 3.3-6 FUNCTIONAL AREA: RADIOLOGY

Description	Assumed Savings Factor	Estimated Displaceable Costs by Facility: Beaufort 250	Andrews 380	Ft. Dix 750
Reduction in patient stay	1 day	$12,000	$23,000	$105,000
Elimination of lost test results	10	12,000	52,553	73,000
Reduced raw food cost	10	13,000	31,600	59,000
Fiscal and Supply	10	12,000	25,000	18,000
Square Footage	$47/sq. ft.			
Registrar Dept.		70,030	232,364	19[illegible],844
Medical Records Storage		63,017	101,802	231,210
File Storage (all other)		16,047	55,366	50,384
Totals		$198,124	$521,085	$766,168

TABLE 3.3-7 NON-FUNCTIONAL DISPLACEABLE COST

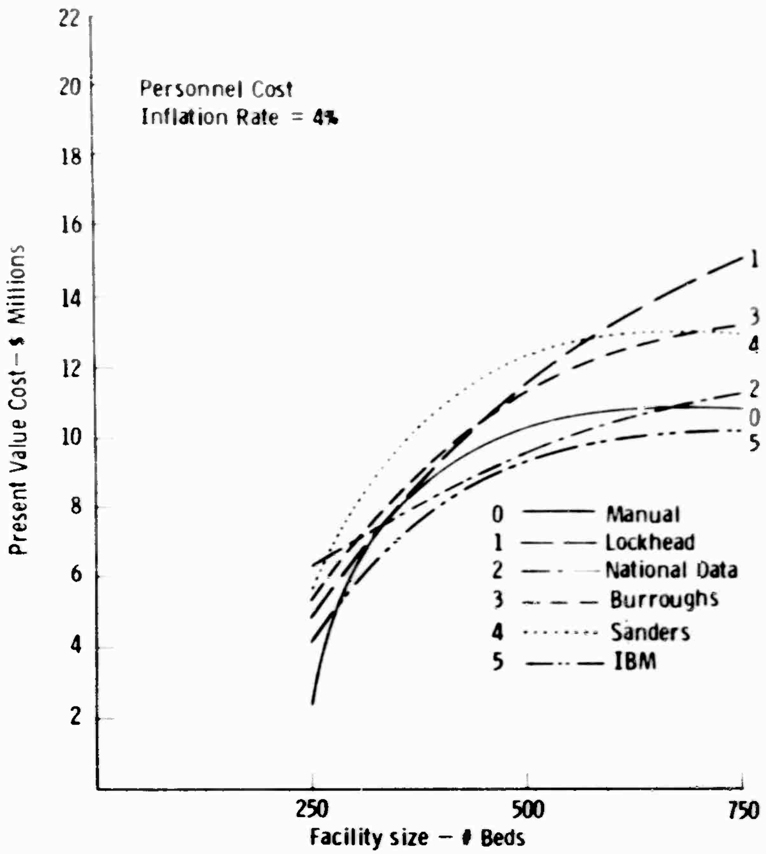


Fig. 3.3-8.1 – Base level health care system information analysis – 4% inflation rate

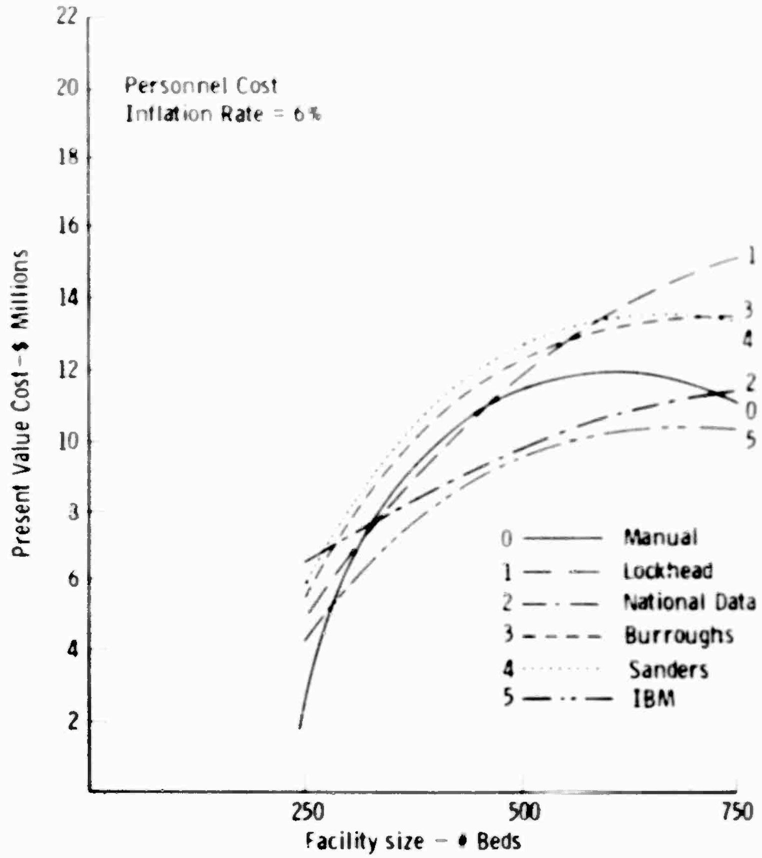


Fig. 3.3-9 – Base level health care system information analysis – 6% inflation rate

Considered in the cost/benefit analysis were changes in discount rate, labor inflation rate, implementation three years after completion of hospital construction, level of patient dependency, and abilities to perform labor-intensive tasks. Conclusions are:

1. Lowering the discount rate from 10 percent to 0 did not affect the ranking of alternatives; however, cost of the REACH alternative improved enough to closely approximate MISP's.
2. Increasing inflation rates from 4 to 6 percent did not affect the alternatives' rankings.
3. Delaying installation three years did not affect the alternatives' rankings.
4. Changes in the level of patient care could not be quantitatively measured. However, based on the Westinghouse data inventory, communications and data management needs increase directly with increased patient dependency, and computerized information networks would, therefore, become more attractive on a cost/benefit basis.
5. Increasing the workload 30 percent did not affect the alternatives' rankings, and it increased total life-cycle costs only 10 percent. In a 500-bed hospital, a 30 percent increase in total life-cycle costs for REACH or MISP can be tolerated, indicating their abilities to withstand cost estimating errors without sacrificing cost justification.

MATERIEL HANDLING

Because materiel handling involves transporting and distributing a wide variety of equipment, supplies, and reports throughout the BLHC system, the function's needs cannot be adequately fulfilled by one mode of transportation or one piece of equipment. Instead, several improvement alternatives must be combined.

Technical Approach

The Westinghouse technical approach to analyzing materiel handling encompassed a 14-step program, illustrated in time sequence by Fig. 3.3-10, and described as follows:

Step 1 -- determine functions to be included in the study.

Step 2 -- generate alternative design configurations reflecting varying numbers of stories and beds.

Step 3 -- relate each function's floor area requirements to hospital design showing the relative locations of each function. By specifying the areas and adjacencies, the analyst can calculate walking rate and vertical travel time.

Step 4 -- compute point to point distances, horizontal and vertical utilizing the results of steps 2 and 3.

Step 5 -- determine function adjacencies and patient distribution by care level. The amount of materiel handling will vary with patient mix; for example, the relative proportion and distribution of bedcare and self-care patients, outpatients, surgical cases, and deliveries.

Step 6 -- collect materiel movement data for each BLHC System, and convert the data to a standard format describing daily activity in cubic feet with suggested delivery times and frequencies. To further establish data describing current practice, an activity plan for each of the model hospitals was made,

showing trips/day and cubic feet of supplies received by (Figures 3.3-11-3.3-14. The activity plan related daily trips and daily cubage by origination/destination pairs.

Step 7 -- reaggregate original data to obtain new travel matrix for each design configuration.

Step 8 -- determine the effects of improvement alternatives on hospital materiel flow. When any alternative is selected because of cost effectiveness, significant changes in materiel flow patterns can be expected. To calculate the equivalent annual cost of automated distribution, for example, requires only that the travel matrix be adjusted, while other factors remain constant.

Step 9 -- define and describe alternatives to be analyzed, based on their abilities to meet evaluation criteria.

Step 10 -- determine adjusted travel matrix for each design configuration.

Step 11 -- calculate annual labor costs for each design configuration.

Step 12 -- obtain capital and incremental construction costs for each configuration.

Step 13 -- calculate life cycle labor costs.

Step 14 -- convert all costs into single equivalent annual cost using the present value method over the alternative's life cycle.

Present Alternative

Data gathered in eight military hospitals as well as in a previous study on the volume, frequency, and timing of materiel handling are detailed in the Data Inventory volume of this report. At present, all materiel handling in military hospitals is done by personnel who push carts, carry packages, and generally act as carriers and transporters. Supply closets and carts are located at the ward unit and are refilled from a central supply closet by orderlies as stock becomes low or sometimes not until a need arises. This results in poor inventory control and increased cost through inefficient utilization of nursing

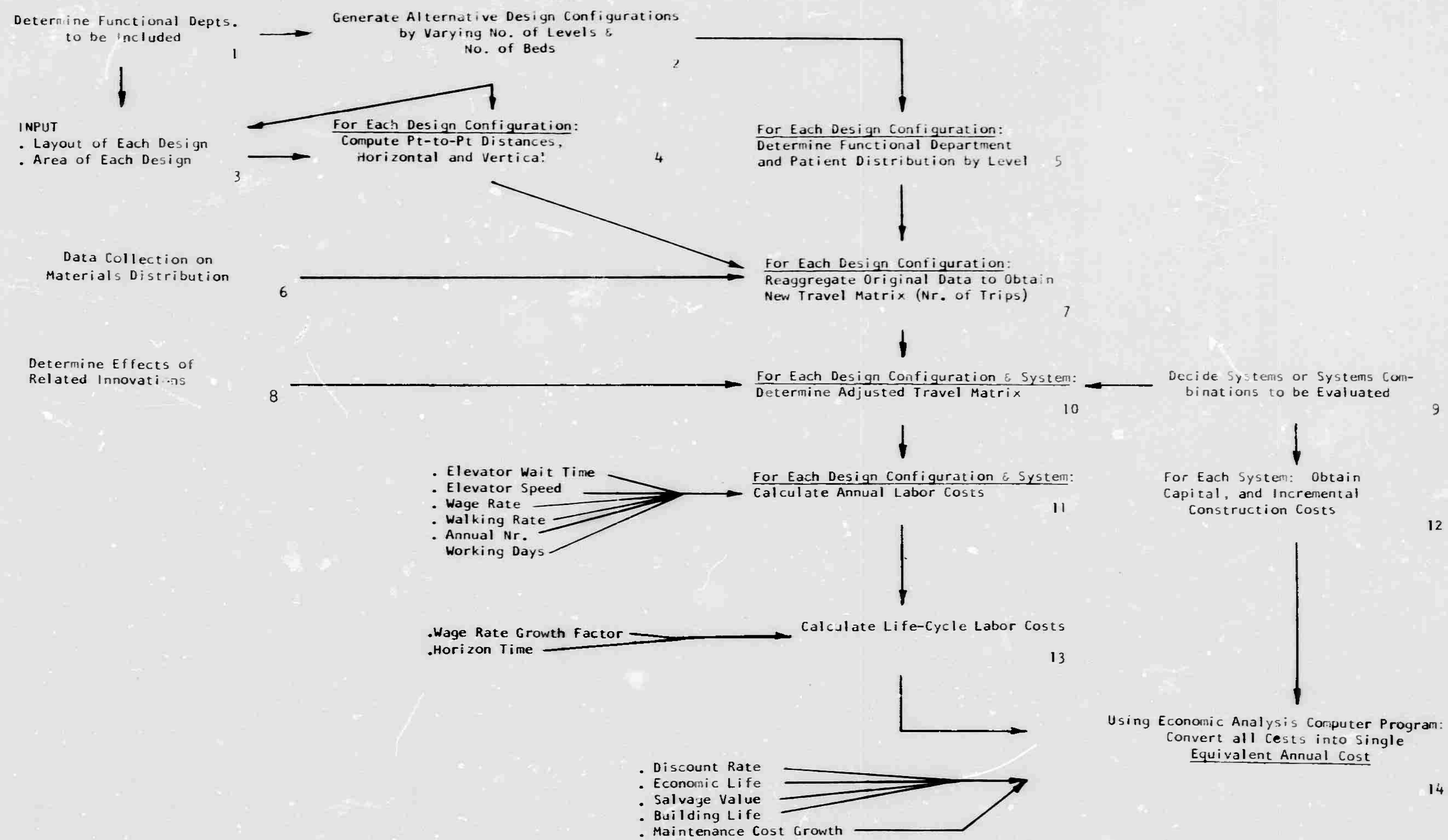


Fig. 3.3-10 —A generalized methodology for evaluating Hospital Distribution Systems

Figure 3.3-11 - Departure Trips From Food Service,
750-Bed Hospital

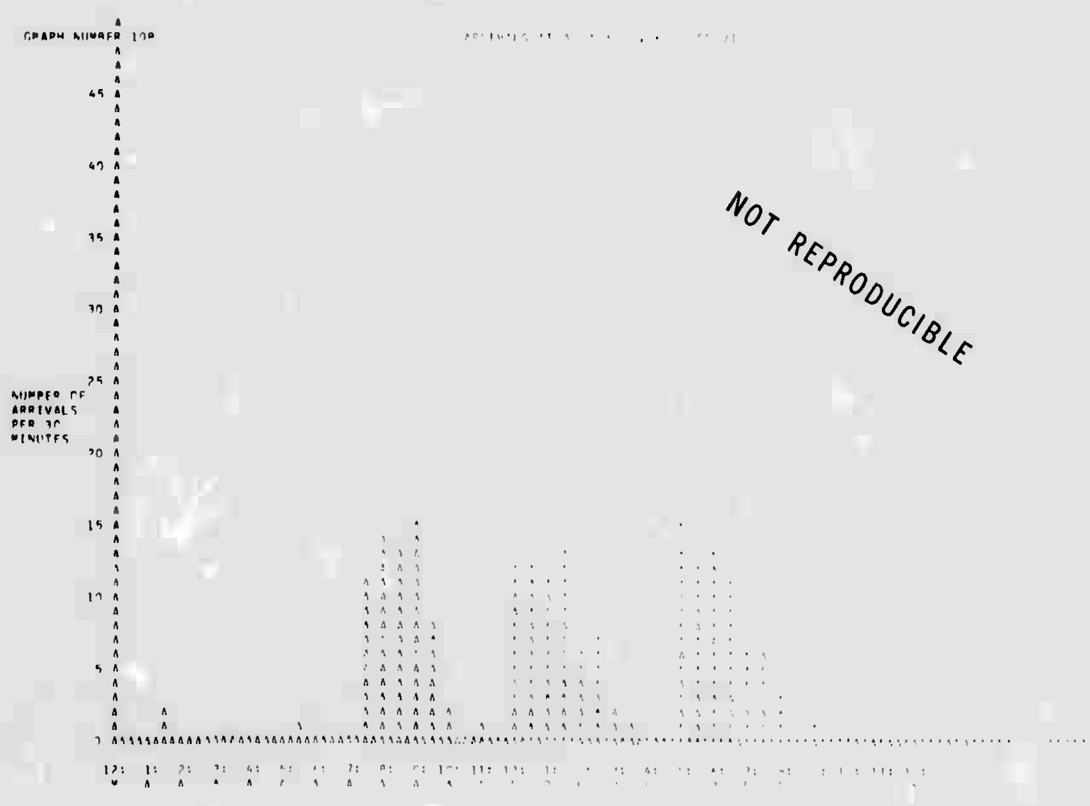


Figure 3.3-12 - Arrival Trips to Food Service, 750-Bed Hospital

Figure 3.3-13 - Total Trips, Arrivals and Departures for Food Service, 750-Bed Hospital

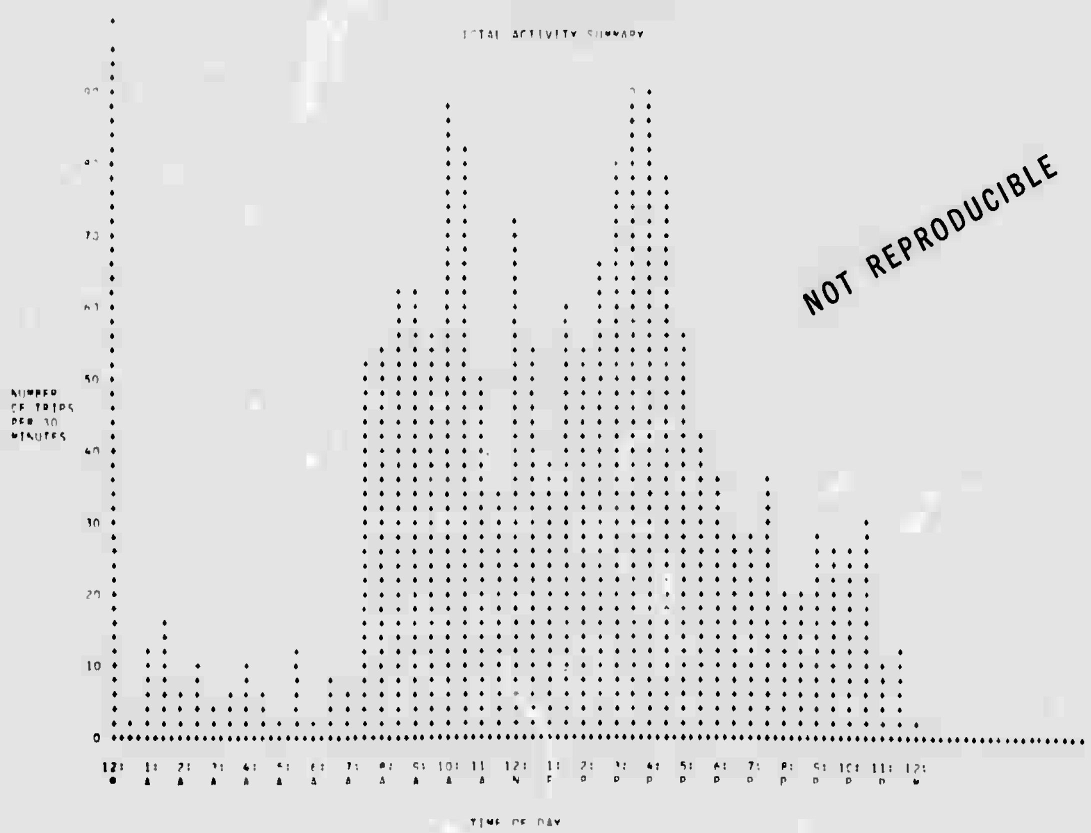


Figure 3.3-14 - Total Trip Summary for 750-Bed Hospital

unit personnel. Moreover, because the possibility of running out of a particular item is unnecessarily great, physician's time is often wasted while necessary supplies are being obtained. This may lead to medical procedures being postponed and patient stays being increased.

Analysis of the data collected by the Westinghouse Study Team resulted in several key findings. First, the patient must be supported by a wide variety of interdependent communications and physical transport services which require a wide array of both simple and sophisticated equipment. Second, materiel handling volume, frequency and timing, and communications are highly sensitive to hospital configuration, that is, number of stories versus number of beds. Third, selection of materiel handling alternatives is affected by patient mix, walking speed and the technology level of other functions such as dietary, pharmacy and communications. These sensitivity factors are discussed in detail in the cost/benefit analysis.

Improvement Alternatives

Westinghouse analyzed five improvement alternatives, ranging from completely manual to highly automated, which appear to offer the greatest potential for cost savings. A detailed qualitative evaluation of the five alternatives is presented in Table 3.3-7.1.

1. The first alternative is a combination of the best manual approach and exchange carts. Two carts are assigned to each nursing unit for each supply area considered; one cart serves as a storage unit on the floor while the other is being refilled to the proper inventory level in the supply areas. The carts are rotated between the nursing unit and central supplies or other supply areas at a convenient time (usually daily) from a traffic and workload viewpoint. IV solutions, tongue depressors, linens, and other items which have a predictable use factor are distributed by exchange carts; meals and drugs are handled independently. With exchange carts,

Improvement Alternatives	Safety	Flexibility	Expansion Possibilities	Appearance and Cleanliness	Operation	Control	Personnel	System Capacity	Amount of Automation	Mobility Factors	Noise Level	Implementation
[illegible]	Fire and collision safety, both good.	Adaptable to all types of loads, carrier itself, inflexible, poor flexibility for different hospital types and sizes, good response to urgent requests	Can easily be expanded vertically in same buildings, horizontal expansion, difficult.	Attractive and clean.	Moderate changes required in methods, procedures, schedules, movement causes heavy damage to floors and walls.	Central, carrier, and station control good, inventory control fair.	Fairly economic operation with reduced staff, low training requirements, personnel training available.	220 lb. per container	Automatic loading/unloading able to move automatically or manually, requires great centralization.	Both vertical and horizontal movement, multi-destination programming, fair intradepartmental travel, separated from other traffic, separates clean and soiled, reduces regular corridor traffic.	unknown	Many construction changes required.
Driverless Truck	Fire safety, good, collision safety, fair.	Can carry up to 90% of all items required in hospital operation, carrier itself, inflexible; flexibility for different hospital types and sizes, fair, fair response to urgent requests.	Same building horizontal and different building expansion, good, same building vertical expansion, fair.	Attractive and clean.	Moderate changes required in methods, procedures, schedules, movement causes moderate damage to floors and walls.	Central, carrier, and station control poor, inventory control fair.	Fairly economic operation with reduced staff, low training requirements, personnel training available.	1,550 lb. per container	Able to move automatically or manually, requires manual loading/unloading, requires moderate centralization.	Both vertical and horizontal movement, multi-destination programming, good intradepartmental travel, little separation from other traffic, does not separate clean and soiled, does not reduce regular corridor traffic.	unknown	Use of exclusive elevators required.
[illegible] Assist	Fire safety, good, collision safety, good.	Poor load type flexibility, carries only linen or trash; carrier itself, inflexible, flexibility for different hospital types and sizes, good, poor response to urgent requests.	Fair expansion possibilities horizontally or vertically in same or different buildings.	Attractive and clean.		Central, carrier, and station control good.	Very economic operation with reduced staff, low training requirements, personnel training available.		Unable to move manually, requires manual loading/unloading, requires great centralization.	Both vertical and horizontal movement, no multi-destination programming, poor intradepartmental travel separated from other traffic, separates clean and soiled, reduces regular corridor traffic.	unknown	Many construction changes required.
[illegible] and Free	Fire safety, good, collision safety, poor.	Good flexibility with type of load, carrier itself, and hospital type and size, fair response to urgent requests.	Same building horizontal and different building expansion fair, same building vertical expansion difficult.	Fair appearance and fairly clean.	Moderate changes required in methods, procedures, schedules; movement causes moderate damage to floors and walls.	Central, carrier, and station control poor; inventory control fair.	Fairly economic operation with reduced staff, low training requirements, personnel training available.	600 lb. per container	Able to move manually, requires manual loading/unloading, requires moderate centralization.	Both vertical and horizontal movement, no multi-destination programming, good intradepartmental travel, some separation from other traffic, separates clean and soiled, does not reduce regular corridor traffic.	low	Moderate construction changes required, use of exclusive elevators required.

TABLE 3.3-7.1 QUANTITATIVE EVALUATION OF ALTERNATIVES

the number of steps in the distribution cycle can be reduced from seven to one.

Present linen distribution involves the following steps:

a. Remove linen from folding table onto cart

b. From cart onto linen room shelves

c. From linen room shelves onto cart

d. Take carts to floor

e. Unload linen from cart and place in floor linen cupboard

f. Count and load onto cart

g. Distribute to patients' rooms.

The exchange cart alternative involves only three steps and can also be used for central supply items sent to the wards.

a. Load linen onto cart

b. Take cart to floor storage area - carts serve as linen storage, and new carts are delivered once every 24 hours

c. Use carts to deliver linen to patient's room.

Installation of the exchange cart in a 360-bed hospital in Cincinnati (Christ Hospital) resulted in a savings in linen distribution of over $9,000 per year.

2. Monorails are the most sophisticated improvement alternatives and require the least personnel. According to extent of installation, they may be:

   a. Installed throughout the hospital for vertical and horizontal traffic. Monorails are economical only in large hospitals with many service points and level changes.

   b. For horizontal distribution only, with automatic transfer to automatic load-unload dumbwaiters for vertical transport. This type of installation is more economical in compact hospitals and low volume requirements and few vertical service shafts.

Monorails u[illegible] a single-track network which can be installed horizontally and/or vertically throughout the hospital between receiving and dispatch stations. Track is arranged in one-way loops to allow continuous flow. Self-propelled and sterilizable transporters, each with an easily detachable container, transport all materiel. Receiving and dispatch stations are strategically located and equipped with controls to allow operators to send or receive transporters to or from any station.

3. The driverless truck is a battery-powered self-propelled cart, guided by wires embedded in the floor. It can deliver 90 percent of all hospital supplies to any point in the hospital without human assistance. The trucks can move vertically in specially designed elevators.
4. Power-and-Free equipment uses power chain (trolley) conveyors and free monorails to carry the conventional hospital cart throughout the hospital. Half-length carts can be used to transport meals and surgical or obstetrical kits. Carts are dispatched from central supply and are automatically transported to their destination. Horizontal and vertical movement is possible.
5. Airtube assist is limited to transporting soiled linen and trash from multiple locations to a central collection point. Cylindrical tubes transport materiel using negative pressures supplied by a suction blower. The number of depository stations is unlimited, and operation is effective with tube lengths of up to 2,000 feet.

Other alternatives such as pneumatic tubes and vertical and horizontal conveyors were considered in the State of the Art volume but not analyzed in detail because their advantages and disadvantages are well known.

Conclusions

1. Manual materiel handling systems have proven to be the least costly and the most flexible for practically all BLHC System sizes and configurations.
2. The only mechanical devices that can be cost-justified for the BLHC Systems are automatic dumb waiters. Even so, these can be cost justified only when associated with high-volume, high - frequency type of movement associated with conventional dietary systems.
3. Large-cross-section pneumatic tubes can be cost justified for the removal of soiled linens and trash. These systems are superior to the more conventional gravity systems because their potential for horizontal as well as vertical transfers allows the designer greater flexibility in locating the collection, compaction, or treatment functions. The annual cost for Airtubes is easily justifiable by personnel time saved. In the 750-bed hospital this is also the lowest cost alternative.

Recommendations

1. A manual materiel handling system utilizing exchange carts is recommended for all new BLHC Systems. All major items should be supplied from central storage, processing, or dispensing areas.
2. The feasibility of introducing exchange cart procedures into existing BLHC Systems, should be investigated as soon as possible.
3. Large-cross-section pneumatic tubes should be installed in all new BLHC Systems to accommodate high-volume, high frequency trash and soiled linen removal.
4. Automatic dumb waiters should be investigated for limited use in situations where high-volume, high-frequency non-level workload patterns occur, for example, conventional dietary systems.
5. The Study Team recommends that design and manpower criteria be revised to allow implementation of the above recommendations.

6. The Power-and-Free alternative should be considered for 200- to 300-bed and 700- to 800-bed hospitals; cost curves indicate that the alternative becomes cost-attractive for small and large hospitals.

Evaluation Assumptions

In developing costs, the following assumptions were made:

1. Useful life of 25 years
2. No salvage value at end of useful life
3. Elevator speed, 200 fpm; elevator wait time, 40 sec.
4. Annual rate of personnel cost escalation -- 4 percent
5. Average distance between vertical transportation system and point of delivery - 70 feet.
6. Average direct personnel costs -- $5500/year
7. Average indirect personnel cost - $1100/year
8. Annual rate of operating cost escalation - 4 percent
9. Discount rate for cost of money - 10 percent

Evaluation Criteria

In addition to cost, several major subjective criteria were used in the evaluation:

1. Manpower availability. As an alternative becomes more sophisticated (or automated), the number of men needed for materiel handling decreases, but their skill levels often increase dramatically. While personnel at even presently needed skill levels are increasingly difficult to find, the highly skilled personnel needed for the more sophisticated alternatives are, and will continue to be, scarce and costly. Therefore, present and long-range local labor conditions must be evaluated prior to making final recommendations.
2. Flexibility, or an alternative's ability to transport a wide variety of materiel densities and volumes to the correct and convenient point in the hospital, is important. In general, as an alternative's sophistication increases, flexibility decreases. The most flexible

alternative is totally manual. An economical and beneficial compromise must be made to achieve the desired flexibility in terms of hospital design, labor availability, and expansion plans.

3. Expandability can be important if population projection indicates major facility expansion over the system's life. Extremely sophisticated alternatives tend to be difficult to expand, while conventional alternatives are altered simply by adding personnel and storage space.

4. Convenience can be expressed in terms of patient or worker satisfaction with the health care delivered regardless of cost justification. Dumbwaiters, for example, are difficult to cost justify; however, they improve meal aesthetics simply because time between meal preparation and delivery is shortened, enabling the meal to be served at the proper time and temperature. In addition, when used to deliver other supplies, the dumbwaiter may sharply reduce manpower requirements.

Cost Benefit Analysis

Westinghouse evaluations were estimated over a 25-year life cycle based on the evaluation assumptions previously mentioned. Costs are tabulated in Table 3.3-8. Base costs, shown in column 1, have been established for 250- 500-, and 750-bed hospitals. Each hospital is also considered in three configurations: the 250-bed hospital in 2, 3, or 4 stories; the 500 in 3, 4, or 5 stories; and the 750 in 4, 6, or 8 stories.

To determine the sensitivities of the manual alternative, the following changes were evaluated:

1. Reduce walking speed 25 percent.
2. Adding 25 percent to the adjacent distances.
3. Reducing elevator wait time 25 percent.

Analysis shows that costs are relatively sensitive to walking rate, and relatively insensitive to adjacency and elevator wait time because:

1. A 25 percent decrease in walking rates causes a 21 percent annual cost increase.
2. A 25 percent increase in departmental adjacency distances causes approximately 5 percent cost increase.

Alternative	No. Beds	No. Stories	Annual Cost $	Changed Patient Mix No Self-Care Separation	-25% Walk Speed With no Self Care	-25% Adjacent Distances With no Self Care	-25% Elevator Wait With no Self Care	6% Discount	-25% Walk at 6%	25% Adj. at 6%	-25% Elevator Wait 6%	50% Salvage	-25% Walk Speed	-25% Adj.	-25% Elevator Wait	25% Walk	25% Adj.	25% Elevator	[illegible]	Walk	Adj.	Elevator
Manual	250	2(1A)	79,104	29,767	244,477			90,936				79,749							[illegible]			
		3(2A)	90,572	90,232	250,445			92,163				80,141							[illegible]			
		4(3A)	92,041	91,704	274,073			93,390				81,613							[illegible]			
	500	3(1B)	129,441	145,006				132,679				127,996							[illegible]			
		4(2B)	139,909	[illegible]				133,906				129,426							[illegible]			
		5(3B)	142,269	160,214				146,306				141,707							[illegible]			
	750	4(1C)	174,6[illegible]	202,143	244,477	202,143	191,500	185,395	224,936	185,594	175,149	179,165	214,976	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		6(2C)	201,340	227,369	250,445	227,369	216,995	208,500	257,549	209,500	197,691	200,697	246,712	200,697	191,494	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		8(3C)	204,937	231,166	254,073	241,730	231,166	211,360	260,417	221,179	211,369	204,193	250,204	313,356	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Memoral	250	2	(MR)	-				-														
		3	196,109	197,590 to	No Data	No Data	No Data	154,583 to				190,150 to							[illegible]			
			(ER)	145,624				116,943				139,050							[illegible]			
			142,763																			
		4																				
	500	3	(MR)		No Data	No Data	No Data	164,255 to				202,339 to							[illegible]			
		4	205,654	210,935 to				139,196				166,675										
			(ER)	174,113																		
		5	171,352																			
	750	4	(MR)		No Data	No Data	No Data	227,941 to				251,558 to							[illegible]			
		6	290,463	291,744 to				164,151				199,215										
			(ER)	207,887																		
		-	264,927																			
Driverless Truck	250	2																				
		3	130,964	155,196	No Data	No Data	No Data	173,161				14[illegible],202										
		4																				
	500	3																				
		4	144,137	199,770	No Data	No Data	No Data	161,375				159,625							[illegible]			
		5																				
	750	4																				
		6	273,635	250,538	No Data	No Data	No Data	225,479				96,670							[illegible]			
Portable	250	2																				
		3	94,792	100,413	No Data	No Data	No Data	74,236				93,112							[illegible]			
		4																				
	500	3																				
		4	162,175	165,077	No Data	No Data	No Data	136,044				157,616							[illegible]			
		5																				
	750	4																				
		6	226,669	234,951	No Data	No Data	No Data	190,776				221,331							[illegible]			
		-																				
Airtube Assist Double System Plus Manual	250	2	87,047	91,930	No Data	No Data	No Data	-33,567				-6,945							[illegible]			
		3	79,059	95,941				48,979				-7,790							[illegible]			
		4	90,727	97,630				-5,354				-9,533							[illegible]			
	500	3	129,797	142,222	No Data	No Data	No Data	126,009				127,499							[illegible]			
		4	131,542	153,466				127,409				130,194							[illegible]			
		5	143,535	157,339				139,275				142,091							[illegible]			
	750	4	165,776	171,747	No Data	No Data	No Data	164,549				164,585							[illegible]			
		6	174,970	227,476				177,461				177,316							[illegible]			
		7	199,277	217,994				195,027				196,569							[illegible]			
Airtube Assist Single System Plus Manual	250	2																				
		3	71,117	77,120	No Data	No Data	No Data	19,042				70,429							[illegible]			
		4																				
	500	3																				
		4	122,637	135,041	No Data	No Data	No Data	121,517				122,669							[illegible]			
		5																				
	750	4																				
		6	170,664	201,370	No Data	No Data	No Data	172,136				174,565							[illegible]			
		7																				

END OF SELF-CARE VARIATIONS

END OF 6% VARIATIONS

END OF SALVAGE VARIATIONS

TABLE 3.3-8 MATERIEL DISTRIBUTION COST BENEFIT ANALYSES SUMMARY

3. A 25 percent decrease in elevator wait time will result in a 5 percent annual cost reduction.

Sensitivity analysis was also used to determine the effect, on all alternatives, of the following:

1. A change in labor fringe benefits from 20 percent to 50 percent.
2. A change in self-care patients from 50 percent, which approximates the present observed patient mix, to 0 percent, reflecting the extreme opposite patient mix in a highly acute facility.
3. A change in the salvage value of equipment from 0 percent to 50 percent of initial investment.
4. Varying the discount rate from 10 percent to 6 percent.

Changing salvage values does not affect the ranking of the alternatives, because of the high discount rate and the long life cycle used. For example, the present value of $1,000 to be received in 25 years discounted at 10 percent is only $92. Materiel handling is sensitive for all hospital sizes to the remaining three conditions. Detailed results are shown in Figures 3.3-16 to 3.3-19, (Figure 3.3-15 is the norm against which subsequent graphs are arrayed).

To use the cost graphs, locate the hospital size (number of occupied beds) on the bottom horizontal line and proceed vertically to the cost curves for each alternative. The first curve that is reached will be the most justifiable, and if cost is the primary consideration, all alternatives above the bottom curve can be eliminated. The cost graphs shown here give a cost range for each alternative because:

1. The costs were not determined for a specific hospital configuration.
2. Initial costs will vary according to manufacturer.
3. Complexity and completeness of many alternatives will vary.

The curves as they are currently drawn can be used to determine the leading contenders for a given-sized hospital. The contenders can then be evaluated in greater detail for a specific configuration.

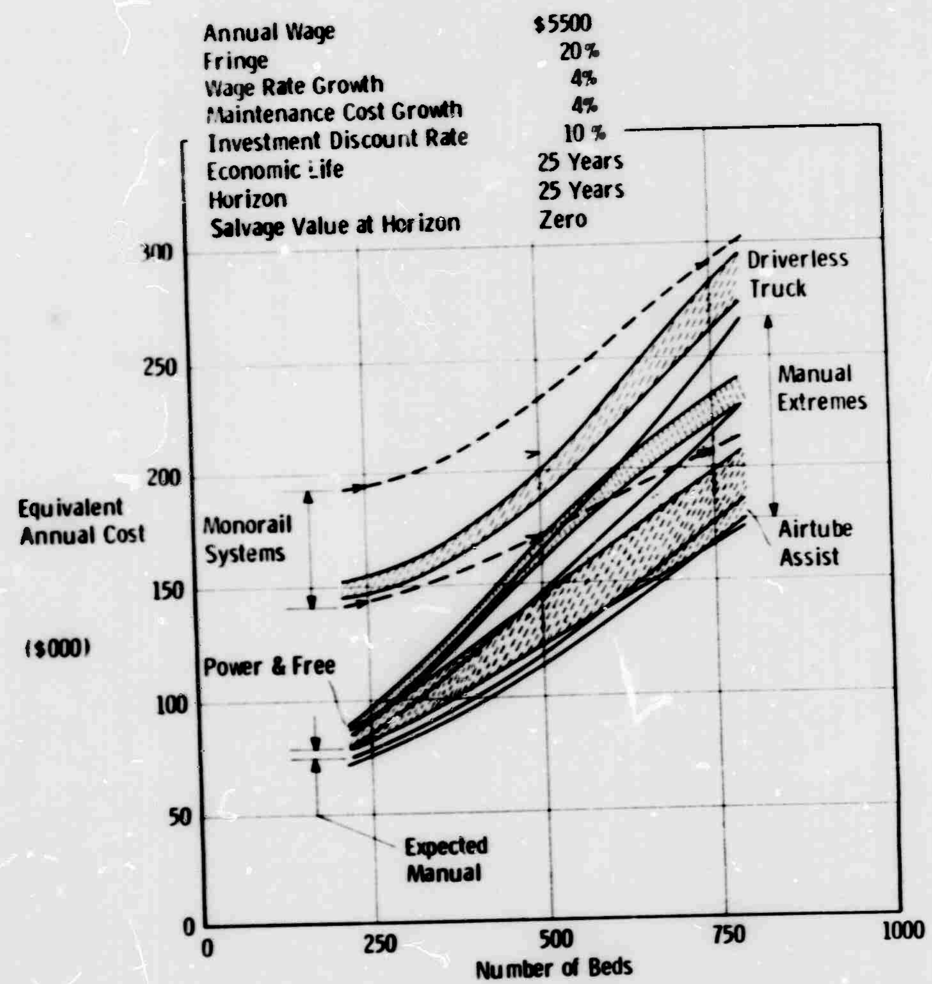


Fig. 3.3-15—Material handling improvement alternatives cost analysis

EQUIVALENT ANNUAL COSTS

FACTOR VARIED: NONE

Variation	Manual	Monorail Max	Monorail Min	Driver-Less Truck	Power & Free	Airtube Dual	Assist Single
1A 250 Beds	79104					88048	
2A	80572	196109	142863	150964	94852	89039	81217
3A	82041					90728	
1B 500 Beds	128441					129798	
2B	129909	208654	171352	194457	162175	131542	122637
3B	142269					143535	
1C 750 Beds	178676		208114			165886	
2C	201340	290463	204927	273635	226669	189770	180664
3C	204938					198287	
1C −25% Walk Speed	215487						
2C	247355						
3C	250953						
1C +25% Adjacent Distance	178676						
2C	201340						
3C	214141						
1C −25% Elevator Wait	169473						
2C	192138						
3C	204938						

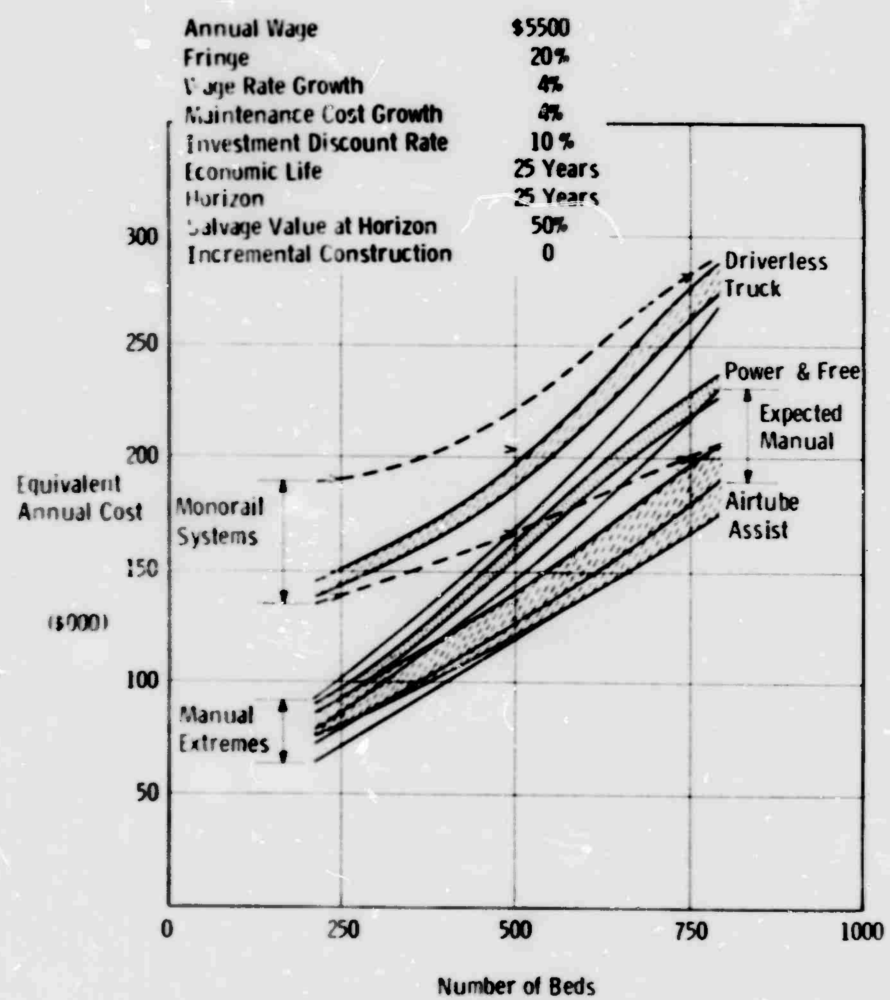


Fig. 3.3-16—Material handling improvement alternatives cost analysis

(50% salvage value at horizon)

EQUIVALENT ANNUAL COSTS

FACTOR VARIED 50% SALVAGE

Variation		Manual	Monorail Max	Monorail Min	Driver-Less Truck	Power & Free	Airtube Dual	Assist Single
1A	250 Beds	78748	190380	[illegible]	117202	93112	86945	80429
2A		80181					87890	
3A		81613					89533	
1B	500 Beds	127996	202539	166675	189628	158616	128499	121669
2B		129428					130194	
3B		141707					142091	
1C	750 Beds	178165	281859	199215	266670	221331	164595	179565
2C		200697		202024			188316	
3C		204193					196569	
1C	−25% Walk Speed	214976						
2C		246712						
3C		250208						
1C	+25% Adjacent Distance	178165						
2C		200697						
3C		213396						
1C	−25% Elevator Wait	168962						
2C		191494						
3C		204193						

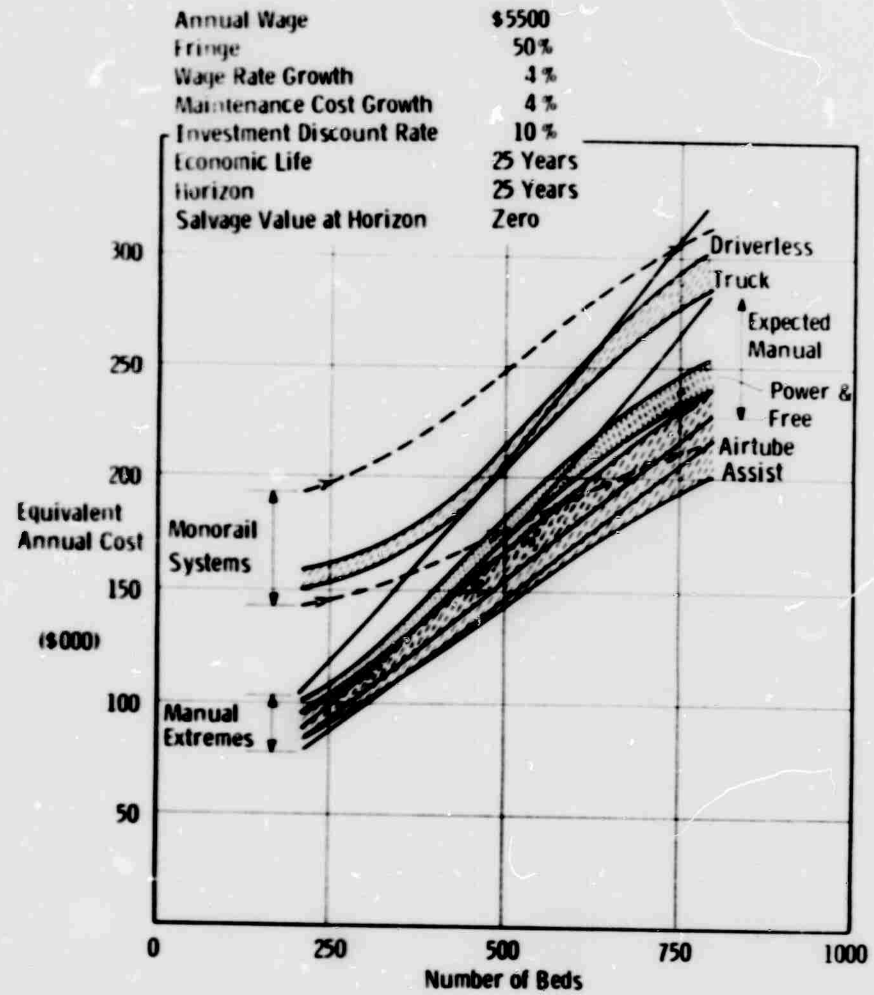


Fig. 3.3-17—Material handling improvement alternatives cost analysis

(50% fringe benefit)

EQUIVALENT ANNUAL COSTS

FACTOR VARIED 50% FRINGE

Variation	Manual	Monorail Max	Monorail Min	Driver-Less Truck	Power & Free	Airtube Dual	Assist Single
1A 250 Beds	95209					99551	
2A	96377	198410	147465	157866	102979	100543	92721
3A	98116					102232	
1B 500 Beds	156049					150504	
2B	157518	210955	175954	202545	173678	152218	143344
3B	172178					166542	
1C 750 Beds	217788	221919				196354	
2C	245054	301268	209528	285139	240473	224281	215174
3C	218652					232798	
1C -25%	263803						
2C Walk	302572						
3C Speed	306176						
1C +25%	217788						
2C Adjacent	245054						
3C Distance	260155						
1C -25%	206285						
2C Elevator	233551						
3C Wait	218652						

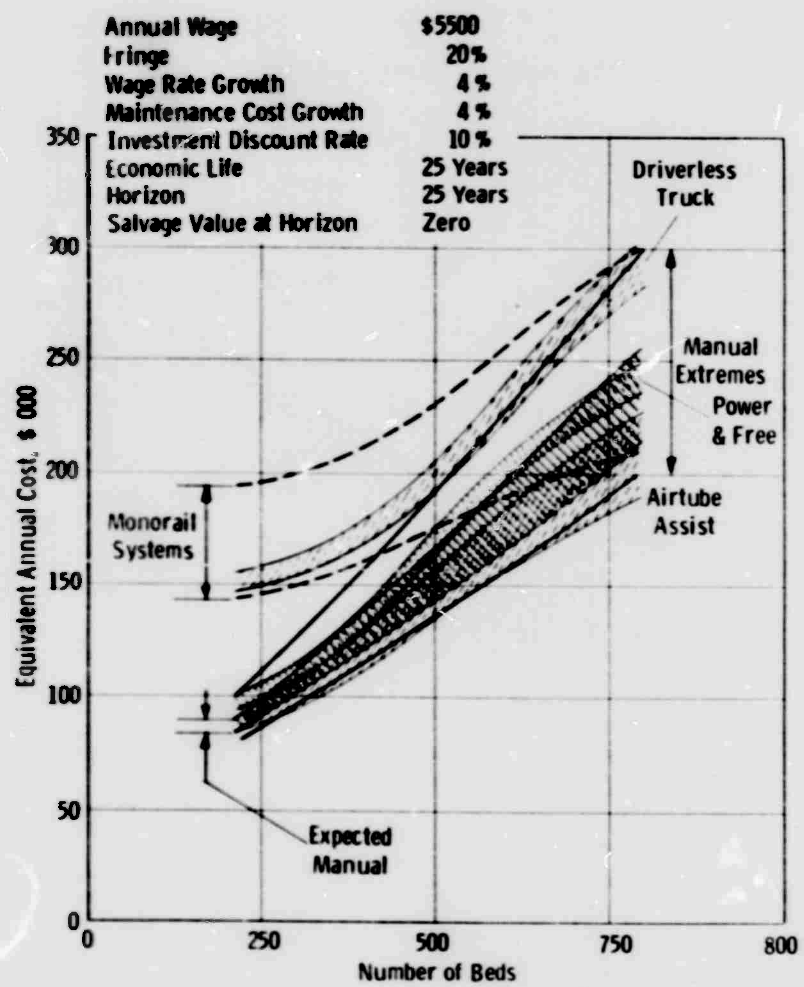


Fig. 3.3-18—Material handling improvement alternatives cost analysis (no self-care separation)

EQUIVALENT ANNUAL COSTS

FACTOR VARIED NO SELF-CARE SEPARATION

Variation	Manual	Monorail Max	Monorail Min	Driver-Less Truck	Power & Free	Airtube Dual	Assist Single
1A 250 Beds	88767					94950	
2A	90235	197490	145624	155106	100413	95941	88120
3A	91704					97630	
1B 500 Beds	145006					142222	
2B	146474	210035	174113	199979	169077	143966	135061
3B	160214					157339	
1C 750 Beds	202143	209495				183748	
2C	227569	291844	207687	280538	234951	210476	201370
3C	231166					218994	
1C -25%	244177						
2C Walk	280485						
3C Speed	284083						
1C +25%	202143						
2C Adjacent	227569						
3C Distance	241750						
1C -25%	191560						
2C Elevator	216985						
3C Wait	231166						

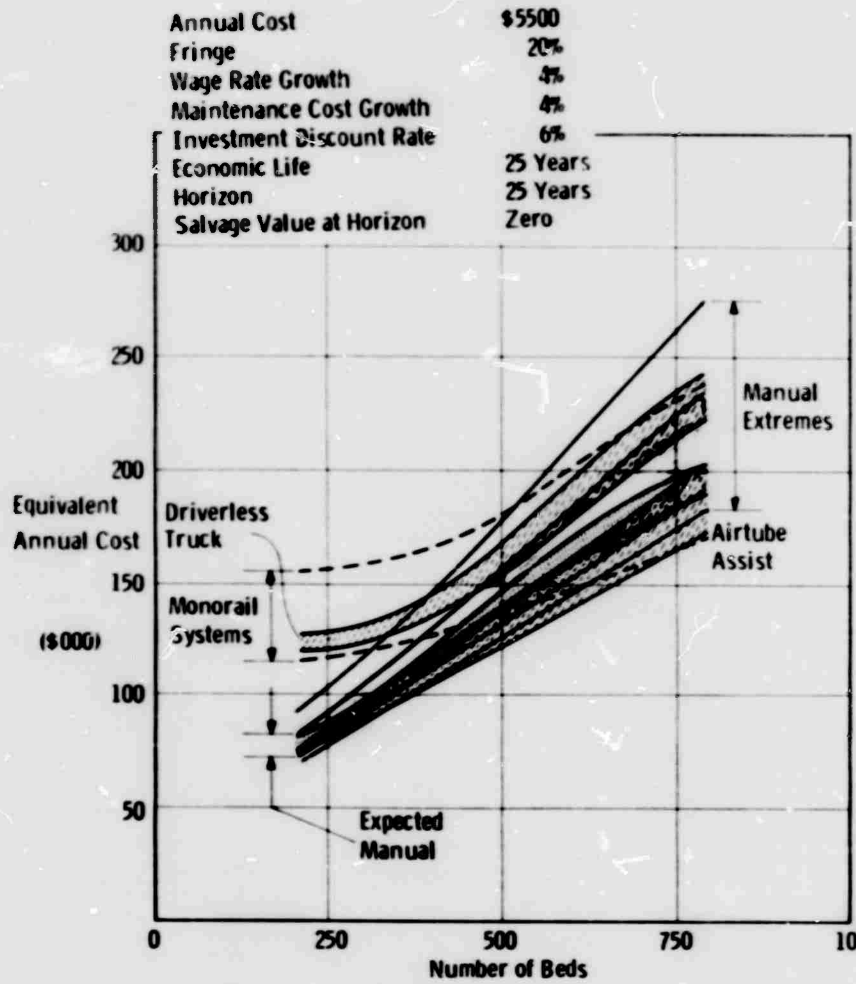


Fig. 3.3-19—Material handling improvement alternatives cost analysis

(6% investment discount rate)

EQUIVALENT ANNUAL COSTS

FACTOR VARIED: INVESTMENT DISCOUNT RATE 6%

Variation		Manual	Monorail Max	Monorail Min	Driver-Less Truck	Power & Free	Airtube Dual	Assist Single
1A	250 Beds	80936					83367	
2A		82163	154583	116013	125161	84236	83989	79082
3A		83390					85354	
1B	500 Beds	132679					126009	
2B		133906	164288	138196	161375	139013	127409	121517
3B		146308					139275	
1C	750 Beds	185598		163949			164519	
2C		208500	227841	164151	225179	190878	188461	182136
3C		211369					195027	
1C	-25%	221836						
2C	Walk	257548						
3C	Speed	260417						
1C	+25%	185598						
2C	Adjacent	208500						
3C	Distance	221178						
1C	-25%	175789						
2C	Elevator	198691						
3C	Wait	211369						

DIETARY

In a conventional BLHC System, raw foods are converted to finished meals in hospital kitchens and transported manually from the kitchen to the wards. Consequently, a disproportionate share of available health care resources are diverted to running and maintaining a restaurant. Administrators at Beaufort, Andrews, and Walson hospitals report that 7 percent to 13 percent of the total operating budget and 9 percent to 12 percent of the personnel are committed to preparing and serving meals.

Modern technology now offers alternative methods which promise to minimize the system's commitment to dietary without diminishing food quality. These alternatives will be measured against their ability to reduce costs through more efficient use of personnel and equipment while maintaining quality.

Our base for comparison is the presently used alternative in which unprepared, uncooked foods are delivered to a large hospital kitchen where they are stored or immediately processed. Processing includes uncrating, sorting, cleaning, cutting, cooking, portioning onto plates and/or trays, and adding utensils. Completed food trays are then placed in heated and/or refrigerated carts, and wheeled to wards where nurses deliver the trays to the patient. Used dishes and trays are picked up by nurses, orderlies, or patients, replaced in the cart, and returned to the kitchen for washing. The entire procedure consumes an inordinate amount of personnel time and is highly inefficient because of peaks and valleys in personnel activity. (See Figure 3.3-20).

In each of the three hospitals studied, non-productive time peaked three times per day and the peaks ranged from 25 percent to 70 percent of total personnel time. The success each hospital has in leveling its workload, however, varied markedly: Walson's non-productive peaks ranged from 34 to 45 percent; Malcolm Grow's from 33 to 43 percent; and Beaufort's from 25 to 70 percent. Also, the peaks occurred at different hours:

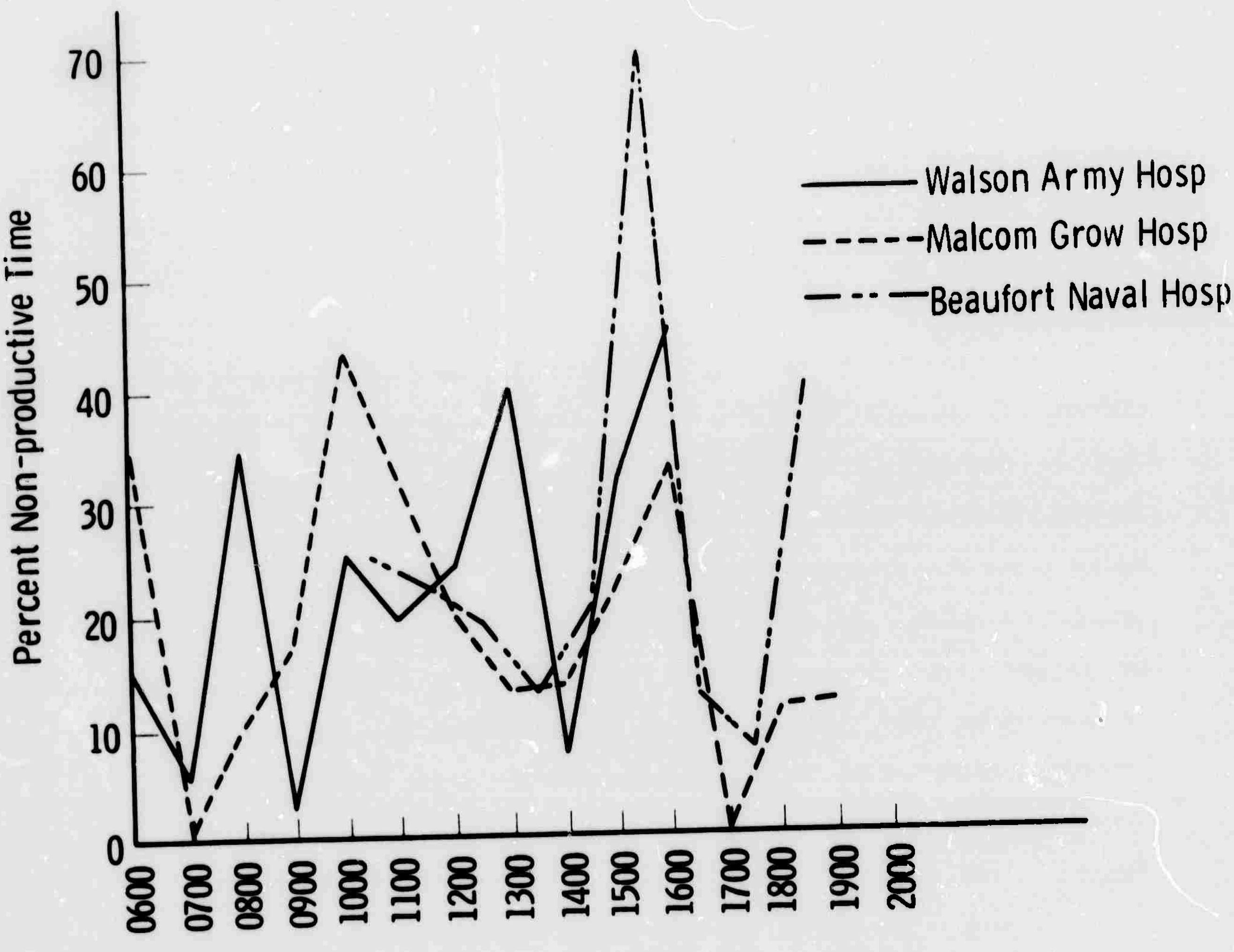


Fig. 3.3-20 Percent of non-productive time of all dietary personnel

Malcolm Grow's at 0600, 0900, and 1600 hours; Walson's at 0800, 1300, and 1600 hours, and Beaufort's at 1030, 1530 and 1830 hours.

Improvement Alternatives

The Westinghouse study considered the nine most important alternatives, including the present method, and evaluated their effects on tomorrow's military hospitals. All alternatives are currently in use or have been sufficiently developed for 1972 implementation. Alternatives 1 through 5 are total concepts serving all the system's needs and can be implemented by themselves. Alternatives 6 through 9 are improvements or modifications to alternatives 1 through 5 and cannot be implemented alone. A description of each alternative follows:

1. The conventional, or base alternative, presently in use.
2. Total use of convenience foods, whereby an outside agency delivers all foods in a prepared and precooked condition. Preportioned individual servings or bulk food is stored in the hospital kitchen at 0^{o} to 42^{o}F, thawed (if necessary) and assembled on trays. and reconstituted (heated) at the ward just prior to serving.
3. Catering, involving complete preparation of all foods by an outside agency. Tray assembly and delivery of unheated foods to the ward for reconstitution will remain the responsibility of the hospital staff.
4. Abbreviated kitchen plus convenience foods which approaches total use of convenience foods, except that foods such as eggs, salads, and special diets which may not be available in convenience form are prepared in a small kitchen. Food is stored in the kitchen and reconstituted at the ward.
5. Internal manufacture of convenience foods, whereby large quantities of a given food are prepared, and then refrigerated or frozen for later serving. Reconstitution takes place at the ward.

6. Automated food delivery involving an automated dumbwaiter device which transports trays to the ward, reconstituting the food on route.
7. Computerized menu planning which plans normal and special diets with high nutritional and portioning accuracy. Its capabilities include recipe preparation (calculating ingredient quantities for a set number of portions) and time sequence display for final meal preparation; it can result in the least cost menu, while maintaining current food quality.
8. Computerized stockroom information management -- computerizes inventory, reorder points, charges and billing data, and also forecasts needs.
9. Use of disposables, such as throw-away utensils and tableware, wherever possible.

Conclusions

1. The conventional dietary system currently used in the BLHC System suffers from two major problems: (a) it is labor intensive; and (b) the nature of the preparation cycle is not amenable to workload leveling.
2. Technology exists which will allow convenience foods to meet the majority of dietary needs in a hospital system.
3. Use of convenience foods together with specially designed kitchens allows individual meals to be portioned and distributed to the wards more uniformly over the working day, resulting in more efficient use of a smaller staff.
4. Only slight additional equipment for reconstituting convenience foods is necessary.
5. Sufficient manufacturers of convenience foods are now available for convenience foods to be used throughout the BLHC System.

6. Sufficient logistical capabilities exist in both the military and civilian environments to ensure that a temporary local dislocation of supplies would not jeopardize a convenience food dietary operation.
7. Use of disposable items for the non-food elements in the dietary system will have considerable impact on dietary waste handling and clean-up operations. However, current studies indicate that disposables are not presently cost justifiable.
8. There is a considerable interface between dietary and materiel handling, with dietary representing the largest single materiel handling load in the typical BLHC System. Leveling the dietary load, therefore, will necessarily benefit the materiel handling workload and reduce manpower requirements.

In all cases, the hospital staff and ambulatory patients will be served in a cafeteria as is currently done, except the food will be convenience foods.

Recommendations

1. Westinghouse recommends that the fourth alternative, an abbreviated kitchen plus convenience foods on each nursing unit, be adapted for all future BLHC facilities and retrofit in existing facilities because:
   a. Although this alternative does not have the least life cycle cost (see Figure 3.3-21), it is superior to the least cost alternative in terms of simplicity, current feasibility, and sensitivity to changes in patient mix and facility size.
   b. The initial investment required at the central kitchen facility and on wards is approximately one-third of that required in the conventional system.

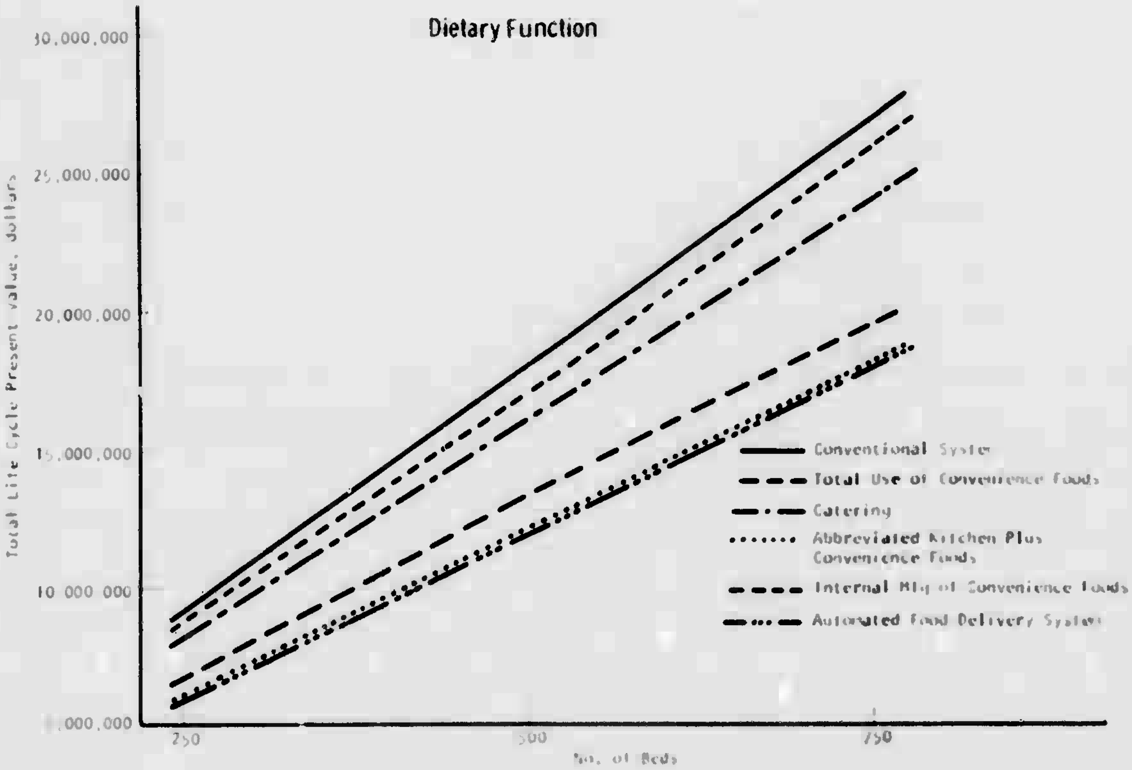


Figure 3.3-21 Total Life-Cycle Present Value Costs for Dietary Alternatives

c. Approximately fifty percent of labor required for dietary will be eliminated. In particular, the highest skill components of this labor are considerably reduced with no loss of nutritional value or patient acceptance of the food.

d. An abbreviated kitchen would provide the small percentage of food stuff currently unavailable as convenience foods.

2. That design and staffing criteria be revised to allow for introduction of the convenience food improvement alternative on a BLHC System-wide basis.

3. Disposables should be used when costs become attractive as a result of new innovations, or the development of mass markets, when dinner ware and utensils can be disposed of without causing pollution.

4. That wherever adequate management systems (preferably computer-based) exist, they should be applied to more economic purchasing and inventory control procedures for dietary.

The Study Team recommends the abbreviated kitchen plus convenience foods, for the following reasons:

1. Total personnel cost will be reduced to 50 percent of the base alternative.
2. Initial investment in space and equipment will be one third less than the base alternative.
3. Food waste is virtually eliminated because most entrees are preportioned.
4. Portions are carefully controlled because food is preportioned.
5. Peak serving demands can be met easily without decreasing quality; tray can be assembled and then refrigerated at other than peak load times; transportation peaks can be leveled because trays can be sent to the wards at any time.
6. Highly skilled personnel are not needed.
7. Meals are more appetizing because they are served hot directly from a microwave oven.
8. Meal can be served at times most convenient to the patient by the corpsmen and aides or ambulatory patients.
9. A complete range of diets can be prepared.
10. Total cost savings over the base alternative for 20 years will be about $2,980,000 for a 250-bed hospital, $6,962,000 for 500 beds, and $8,943,000 for 750 beds.

We also recommend computerized menu planning and stock room information be implemented with the abbreviated kitchen. While cost

savings are difficult to quantify, intangible benefits include:

1. Menus which meet nutritional and preference requirements can be planned at minimum cost.
2. Special and modified diets will be readily controlled.
3. Recipe ingredients will be precisely controlled to eliminate waste.
4. Nutritional requirements for special diets can be rapidly calculated.
5. Inventory, issues, and receipts will be tightly controlled to help reduce costs.
6. Spoilage will be reduced through improved purchasing.

Disposables should be used when costs become attractive as a result of new innovations or development of a mass market, and when the utensils and tableware can be disposed of without causing pollution.

Evaluation Assumptions

Evaluations assumed several cost factors, based on data from the three BLHC Systems studied, literature searches, and data supplied by consultants.

a. Salary of the average dietary worker at the three BLHCS was $7202 annually.
b. Space allocated to the dietary function in the conventional method is 19.9 sq. ft. per bed. This figure is the HAS guidelines for conventional dietary systems. Malcolm Grow and Walson approximate this figure (one on either side), while Beaufort Naval Hospital exceeds it.
c. Cost for dietary space and equipment using present methods is $50 per sq. ft. This figure, used by RTKL, the

architectural firm associated with Westinghouse on this project, compares closely with work done by Stanford University.

d. In the present alternative, one dietary employee is needed for 4.57 beds. This figure was obtained from data at the three BLHCS studied plus figures from HEW and consultants. (See Figure 3.3-22).

e. An average of 4.08 meals per day are served per occupied bed. This figure was obtained from data at the three BLHCS studied and from other sources as shown in Figure 3.3-23, and includes meals served to BLHCS personnel.

f. The cost of supplies is $ .041 per meal based on data obtained at Beaufort, Malcolm Grow, and Walson. This cost is derived from Figure 3.3-24.

g. Annual food cost is $171.39 per daily meal served based on data gathered at the three BLHCS studied. Refer to Figure 3.3-25.

h. In the recommended abbreviated kitchen alternative, corpsmen or aides will reconstitute each meal on the ward prior to serving. Reconstitutions and delivery time will be 1 to 1.25 minutes per tray. Total serving time will be 30 to 37 minutes for a 40-bed ward with 25 percent ambulatory patients.

i. Each nursing unit will need approximately 30 sq. ft. additional space for a refrigerator, hot water and beverage dispenser, a microwave oven or ovens, sink with drain boards, and storage cabinets.

j. Food heating time will be approximately 1 minute per tray.

<u>Evaluation Criteria</u>

An important consideration when choosing a dietary alternative is its ability to handle increased workloads if the hospital extends its services or the patient mix changes. Evaluation of each alternative, therefore,

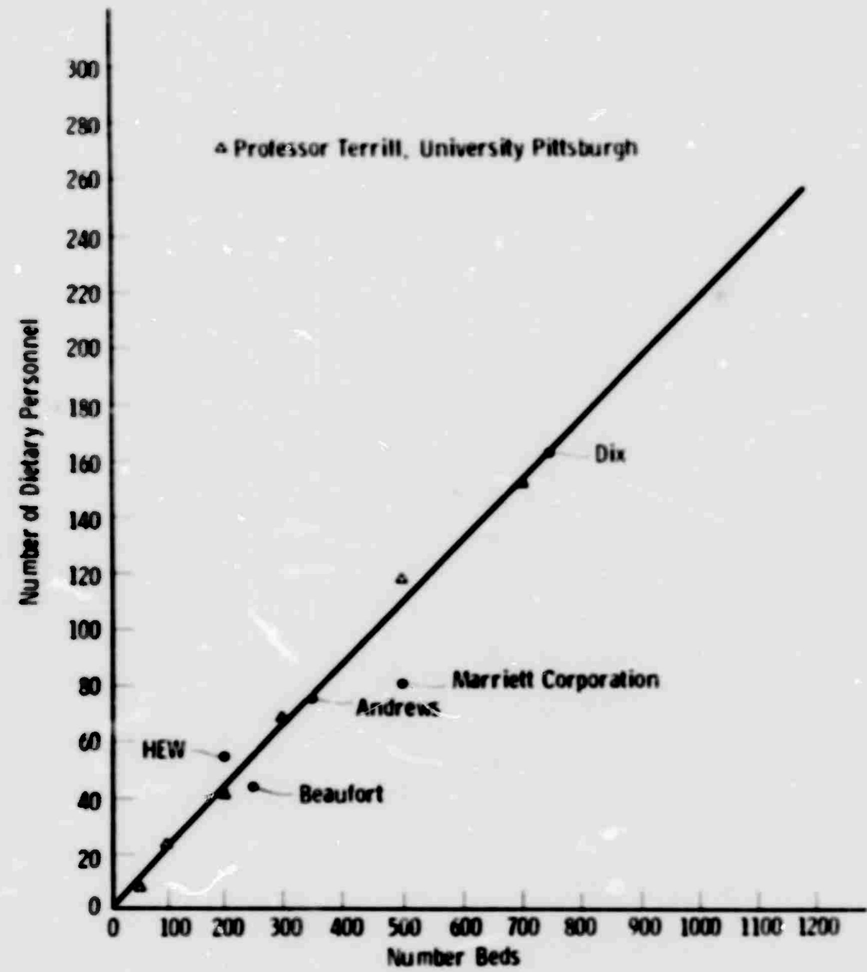


Fig. 3.3-22 —Number of dietary employees

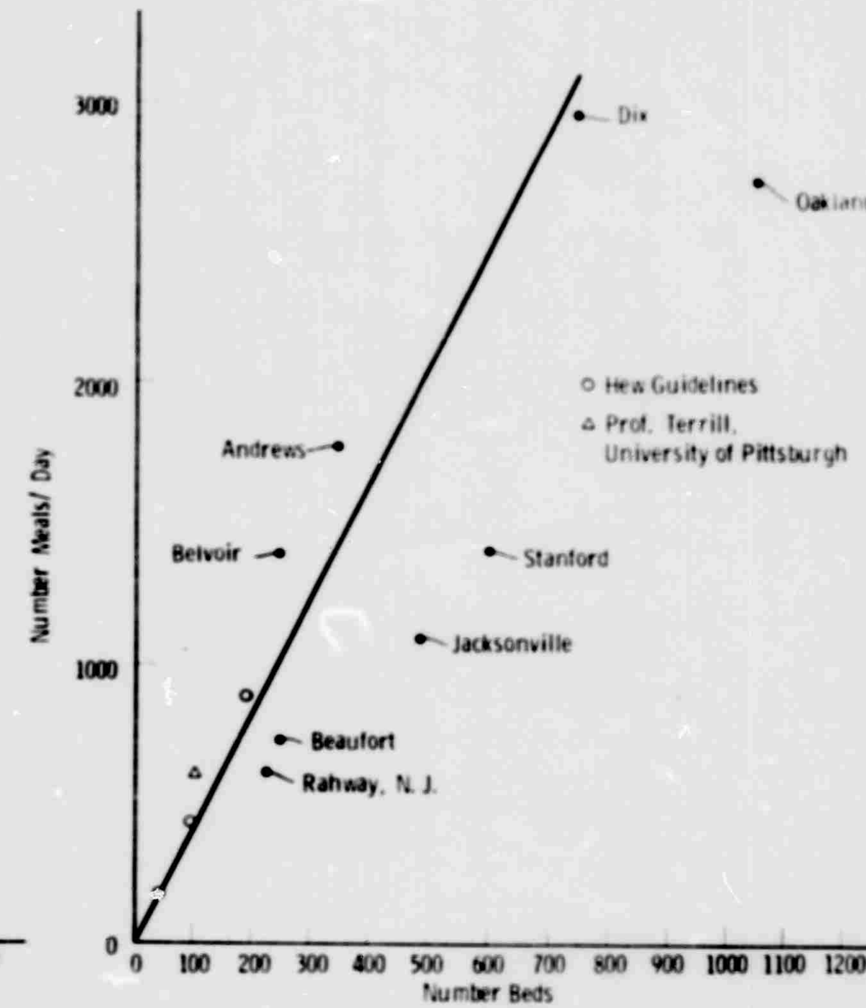


Fig. 3.3-23 —Meals served per day

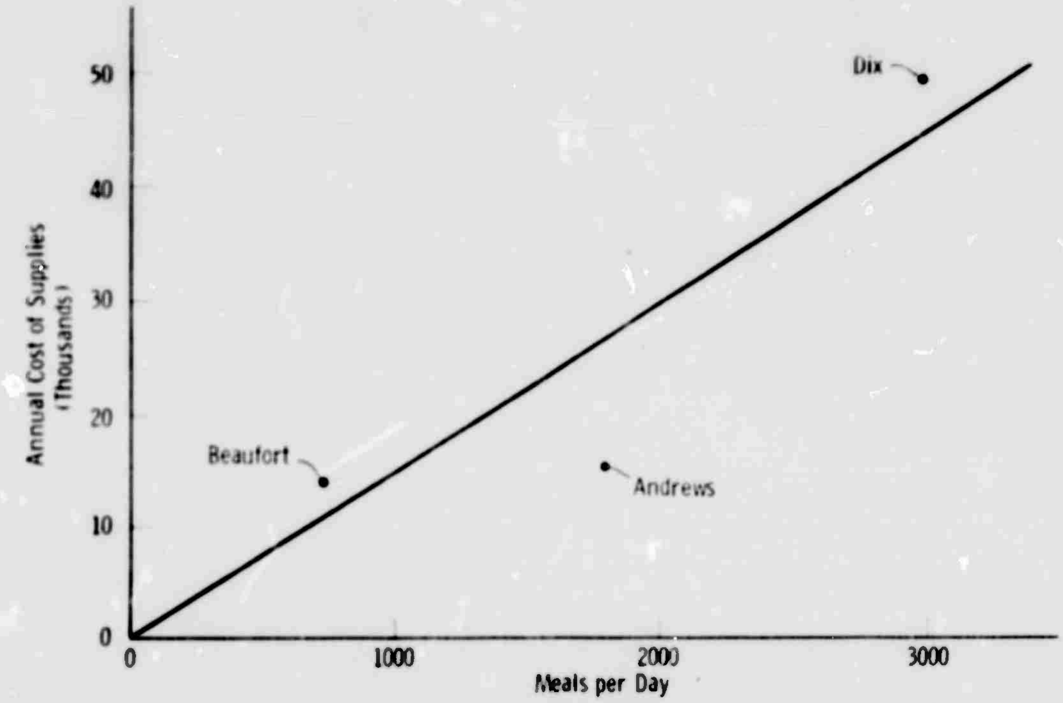


Fig. 3.3-24 —Annual supply cost

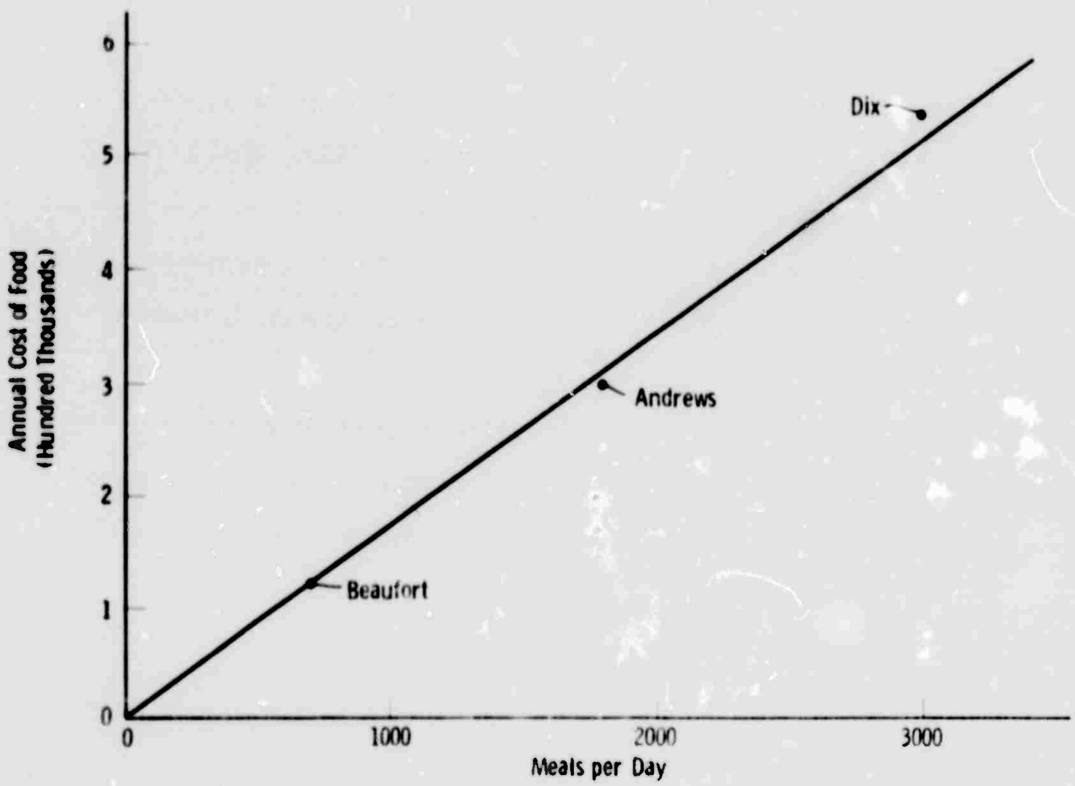


Fig. 3.3-25 —Annual food cost

includes space expansion costs and/or costs of inefficient operations when the alternative is operating at overcapacity.

While we have not developed actual expansion cost estimates, it is logical that alternatives which eliminate or reduce work areas will be more easily expanded. The catering alternative would then have the lowest expansion costs, followed by the use of abbreviated kitchens and convenience food, and by the internal manufacture of convenience foods.

The abbreviated kitchen, used with convenience foods, offers production output flexibility not available in the conventional method because many food preparation and production areas are eliminated. The result is that only storage, tray assembly, and clean-up areas need to increase their productivity to meet expanded needs. This is easily accomplished by preparing trays at off-peak hours.

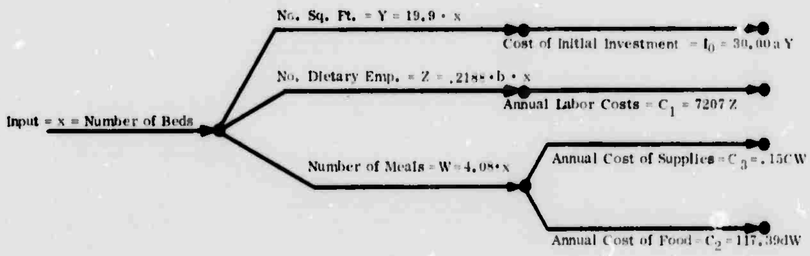
Rahway Hospital in Rahway, New Jersey, illustrates this point. Originally designed to serve 75 beds, the dietary function now serves 224 beds with an increase in dietary space of only 160 sq. ft. to accommodate additional cart storage space. Similarly, Memorial Hospital, Glendale, California, will expand from 320 beds to 460 beds without increasing dietary space.

Because only additional refrigeration space is needed to meet increased demand, the abbreviated kitchen alternative permits hospital expansion without comparable dietary space expansion over an extended time. For example, an increase in refrigerated space equal to one percent of the total dietary space commitment can handle an eight percent increase in hospital size.

Cost/Benefit Analysis

Our analysis was developed in two parts. First, alternatives 1 through 6 were evaluated since they are mutually exclusive; second, alternatives 7 through 9 were evaluated for their effects on alternative 4 (Abbreviated kitchen plus convenience foods).

Costs were developed for the present alternative utilizing the Dietary Cost Tree shown in Figure 3.3-26 and the assumptions and criteria previously discussed. The costs for alternatives #2-6 were developed applying the change constants shown in the alternative change matrix (Figure 3.3-26, the Dietary Cost Tree.) With the Total Convenience Foods alternative, for example, the cost of equipment and space will be 60 percent of that needed for the conventional system. Also, the number of dietary employees will be 50 percent less, with the cost of food 31 percent more. The alternative change matrix described below was developed from an exhaustive state-of-the-art literature search and from consultation with experts in the dietary field.



ALTERNATIVE CHANGE MATRIX

Alternatives	Change Constants a	b	c	d
Convenience Foods	.60	.50	1.00	1.31
Catering	.55	.82	.80	1.12
Abbreviated Kitchen	.66	.50	1.00	1.12
Internal Mfg.	1.05	.95	1.00	1.00
Automated Syst.	5.00	.30	1.31	1.00

Key

a = initial investment
b = annual labor cost
c = annual supply cost
d = annual food cost
Conventional = 1.0

Figure 3.3-26 Dietary Cost Tree

The total life cycle present value by number of beds for each of the first six alternatives are plotted in Figure 3.3-21.

The sensitivity of the alternatives to the following changes in discount rate and the various inflation rates was tested:

Discount Rate	5% to 10%
Inflation Rate:	
Labor	4% to 8%
Food	4% to 6%

Changing the discount rate from 5 percent to 10 percent changed the ratio of present value costs of abbreviated kitchen and convenience foods to the conventional system from 69 percent to 67 percent. When the labor inflation rate changed from 4 percent to 8 percent, this ratio decreased from 69 percent to 64 percent. When the food inflation rate varied from 4% to 6% the ratio changed from 69% to 72%. The rankings of alternatives did not change during these variations. This shows that Dietary is relatively insensitive to changes in discount rate and inflation rates.

To determine the effect of changes in initial investment, personnel costs, and food and supply costs, Table 3.3-9 was developed from the present Value Cost Benefit computer runoff.

This shows that except for the internal manufacture of convenience foods, all alternatives are insensitive to variations in the four cost factors. Since internal manufacture shows only a small savings over the present alternative, it is unimportant that it is fairly sensitive to changes in personnel and food costs.

By analysis of computer output for the life cycle cost studies relating to the dietary alternatives, it was obvious that the major elements affecting life cycle costs were personnel and food costs. Therefore, we estimated how much our predicted personnel and food costs for each alternative could increase before the life cycle cost of an alternative would equal that of the conventional alternative. For example, the estimated labor cost associated with improvement alternative #4 would have to be incorrect by 93% (nearly twice as much as previously estimated) before the life cycle cost of this alternative would equal that of the current system.

The results of the Cost/Benefit Analysis for all alternatives is shown on Table 3.3-10. Based on this analysis, Westinghouse recommends the Abbreviated Kitchen plus Convenience Foods alternative.

TABLE 3.3-9

ESTIMATED ALLOWABLE MARGIN OF ERROR
FOR DIETARY PERSONNEL AND FOOD COSTS*

ALTERNATIVE	PERSONNEL COST	FOOD COST
1. Conventional	-	-
2. Total Convenience Foods	79%	82%
3. Catering	18%	37%
4. Abbreviated Kitchen and Convenience Foods	93%	114%
5. Internal Mfs.	5%	13%
6. Automated	158%	99%

* % Individual Component would have to be increased, all other items remaining as is, to make Present Value Cost equal to Conventional.

TABLE 3.3-10-- DIETARY COST BENEFIT ANALYSIS SUMMARY

Improvement Alternative	Estimated Cost of Supplies/Meal ($)	Estimated Cost of Food/Meal ($)	Estimated Personnel Cost/Year ($)	Estimated Investment Cost for Space and Equipment ($)	Estimated Life Cycle Cost Over 20 Years (Million $)	Estimated Life Cycle Cost Savings (Million $)	Skill Level Low 1 - 5 High	Food Esthetics Low 1 - 5 High	Inventory Control Low 1 - 3 High	Portion Control Low 1 - 3 High	Food Waste
#1 Conventional Method											
250 beds	0.041	[illegible]	395,000	119,000	9,033	-					
500 beds			790,000	298,000	18,067	-	5	5	2	2	Avg.
750 beds			1,182,000	447,000	27,101	-					
#2 Complete Convenience Foods											
250 beds	No change	31% more	50% less	10% less	6,513	2,521					
500 beds	"		"	"	13,026	5,041	2	3	3	3	Good
750 beds			"	"	19,539	7,562					
#3 Catering											
250 beds	20% less	12% more	18% less	15% less	8,062	.971					
500 beds	"	"	"	"	16,125	1,943	1	3	3	3	Good
750 beds	"	"	"	"	24,187	2,914					
#4 Abbreviated Kitchen Plus Convenience Foods											
250 beds	No change	12% more	50% less	33% less	6,052	2,981					
500 beds	"	"	"	"	12,105	5,962	3	4	3	3	Good
750 beds	"	"	"	"	18,157	8,944					
#5 Internal Manufacture											
250 beds	No change	No change	5% less	5% more	8,723	.311					
500 beds	"	"	"	"	17,446	.622	5	4	3	3	Good
750 beds	"	"	"	"	26,168	.933					
#6 Automated											
250 beds	No change	34% more	70% less	500% more	6,008	3,026					
500 beds	"	"	"	"	12,016	6,052	2	3	3	3	Good
750 beds	"	"	"	"	18,024	9,078					
#7 Computerized Menu Planning											
For 500 bed added to #4	No change	0.5% less	No change	No change	12,079	5,988	5	-	-	-	Good
#8 Stockroom Information											
For 500 bed added to #3	0.5% more	0.25% less	No change	No change	12,094	5,974	5	-	3	-	-
#9 Disposables											
For 500 bed system in conjunction with Alt. #3	71% more	No change	Less	Less	14,040	4,027	-	-	-	-	-

CLINICAL LABORATORY

The Clinical Laboratory function accounts for approximately 4 percent of the total BLHCS operating budget. Its importance though is significantly greater than this would indicate, since it performs one of the key elements related to practically all diagnostic activities. Thus delays and inaccuracies in this department result in inefficient use of scarce resources in other larger and more costly sections or departments, for example, unnecessary return visits to the clinics, longer stays in the inpatient facility, or wasted resources in therapeutic areas.

The work load of the Clinical Laboratory function is significantly affected by the rapid rate of change in the practice of medicine. Studies at civilian systems indicate that without increasing the number of patients, the clinical laboratories are evidencing a compound annual rate of increase in the number of tests requested of approximately 15 percent. This represents a hundred percent increase in the workload approximately every six years. Westinghouse studies of BLHC Systems indicated an annual growth rate of approximately 14 percent in the clinical laboratories.

Further analysis indicates that approximately 80 percent of the clinical laboratories operating budget relates to personnel costs and that current design criteria generally allows for automation of only 35 percent of all tests. The clinical laboratory, therefore, is an area where introducing new technology will not only show a cost benefit through reduced total labor or increased throughput but will also provide the capability for more readily absorbing the enormous problem of increased work load.

The physical layout and equipment of a clinical laboratory are largely dependent upon the number and type of tests to be performed, which are, in turn, determined by patient condition, the level of care required, the BLHC System's attitude towards profile testing for routine health checks, and profile testing needs for hospital or dispensary admissions.

The primary objective of the Westinghouse study of laboratory facilities was to identify the most rapid and reliable method for performing tests regardless of cost. The second objective was a reasonable turn-around time; that is,

the length of a patient's stay should not be a function of the time it takes to obtain test results. Third, the possibilities of reducing cost per test were evaluated. Fourth, accuracy of test results were to be improved or maintained; within certain limits accuracy increases as volume increases for both manual and automatic testing.

TECHNICAL APPROACH

The technical approach to studying the clinical laboratories function was:

1. Collect data on effectiveness, cost, and turn-around and solicit suggestions for chemistry, hematology, serology, and blood bank improvement alternatives from laboratory supervisors and hospital administrators at Beaufort and Dix.
2. Study manual and automated techniques available to all departments within the laboratory. (Basic laboratory equipment needed in all laboratories, such as refrigerators, centrifuges, water bottles, incubators, benches, and glassware was not studied.)
3. Evaluate all feasible alternatives and recommend those which best fulfill our objectives.

The Westinghouse team studied all pertinent activities in the test cycle, from the time a physician requests a laboratory test until he receives the results, including support activities such as sample identity and travel throughout the analysis process. All activities were further grouped into common tasks and time needed to complete them via both manual and automatic procedures.

PRESENT ALTERNATIVES

Today's military clinical laboratory is generally not centralized; instead, many differing activities take place in six to eight physically separated areas. Test methods, equipment and costs for reagent, labor, and capital equipment differ between laboratories even within the same branch of the service.

Ten basic laboratory activities are performed in chemistry, hematology, blood bank, serology, bacteriology, histology, and parasitology departments:

1. Communication between physician requesting the test and the laboratory analyst
2. Sample collection and travel
3. Sample identification
4. Centrifugation
5. Setup sample distribution within the laboratory
6. Pipetting, mixing, and incubation
7. Calculations
8. Reagent media preparation
9. Culture and smear
10. Sub-culture.

These activities and how they interact at Beaufort and Dix are discussed in detail in the Data Inventory volume. Personnel time needed for each activity by test type is shown on Table 3.3-13.

IMPROVEMENT ALTERNATIVES

From the state-of-the-art study, nineteen improvement alternatives were selected for detailed analysis. The improvement alternatives have been classified into four broad categories: facility design, manual testing, automated equipment, equipment leasing.

A. Facility Design

Laboratory design will have considerable impact on the effectiveness with which staff can perform the complex and interrelated testing required. Early laboratory designs tended to aggregate spaces related to the major functional breakdown within the overall department. This method of design coupled with the use of solid fixed partitions has generally resulted in inflexible layouts.

Laboratory procedures have already evolved to the point where one single sample from a patient must be split between five to seven functional areas for analysis. Since some departments were built and are operated as separate entities, inefficient processing, sample loss, and identification errors are compounded.

TABLE 3.3-13

PERSONNEL TIME BY ACTIVITY PER TEST TYPE, MINUTES

	Communication	Sample collection and travel	Sample identification	Centrifuge	Setup	Pipetting mixing incubation	Calculations	Reagent (media) prep	Culture
Chemistry									
Manual	1.2	3.5	3	1.4	1.5	3.6	1.5	.1	
A.A. 1 channel	.8	3.5	2.5	1.2	2.3	.3	.8		
Hematology									
Manual	.8	3.5	2.4	-	.7	1.3		.1	1.4
Urinalysis	.7	-	2.4	.5	1	1	.6		.6
Blood Bank									
ABO & RH	1.0	3.5	2.5	-	.9	.95	1.6	.2	
Cross match	.9	3.5	2.6	11.0	5	2.1	2.4	.2	
Serology									
Manual	.6	31.5	2.5	1.4	.7	1.5	.3	.3	
Bacteriology	.81	3	2.5		1	16.8		4.3	.2

Inflexible design layouts based on current functional areas, percentage of work load, and equipment, neglect the fact that as the number of tests are increasing;so is the rate of equipment obsolescence and methodology and the relative importance of any one test area.

The study team evaluated the impact of two design improvement alternatives on the operational clinical labs:

Alternative (1) Centralization of all laboratory functions rather than compartmentalization within a central facility or remotely located functional areas.

Alternative (2) More flexible design of the Clinical Laboratory both in terms of the ability to respond to internal changes and the ability to grow.

B. Manual Testing Equipment

Manual testing is most applicable to laboratories with low test volumes and to facilities where tests are performed in Dispensaries. Three equipment alternatives were considered, all applicable to chemistry analyses in a dispensary and all requiring a colorimeter, an incubator, and a centrifuge.

Alternative (3) Ames/BMI blood analyzer, which uses a spectrophotometer with four available wave lengths and can perform 14 separate tests at a rate of 20 to 60 tests per hour.

Alternative (4) The Bio-Dynamics Unitest analyzer which uses a single wavelength spectrophotometer, and can perform 9 separate tests at a rate of 20 to 40 tests per hour.

Alternative (5) The Dow analyzer, which uses a single wavelength spectrophotometer, and can perform 9 separate tests at a rate of 20 to 40 tests per hour.

C. Automated Equipment

Automated equipment can reduce the cost per test, standardize test procedures, and improve the quality of results (well trained technicians must be available). However, automation cannot be cost justified for low test volumes, for example, when equipment is used less than three to four hours per day or performs less than about 20 tests per day. Manufacturers' claims for

attractively low test costs are generally based on six to eight hours per day operation, and assume a volume which is extremely difficult to achieve even at large hospitals such as Ft. Dix. Also, the higher technician skill requirements pose personnel availability problems. The following automated equipment alternatives were analyzed, by function, within the department:

I. Hematology Department

Alternative (6) Coulter Counter, Model FN, (Coulter Electronics) is a single-channel particle counter and sizer, capable of counting particles in a sample of diluted blood.

Alternative (7) Coulter Counter, Model S, is a seven-channel particle counter and sizer, which can count particles in a diluted blood sample.

Alternative (8) Fischer Autocytometer is a single-channel blood cell analyzer.

Alternative (9) The Technicon SMA 7A is a seven-channel particle analyzer.

II. Blood Bank Department

Alternative (10) Technicon Auto-analyzer is a dual-channel ABO and RH typer.

Alternative (11) The fifteen-channel Technicon Auto-analyzer is an ABO, RH, and RH subtypes analyzer.

III. Chemistry

Alternative (12) The Beckman DSA-560 is a single- or dual-channel discrete sample analyzer which can complete 160 tests per hour.

Alternative (13) Mark X (Hycel Instruments, Houston) is a discrete sample profile analyzer with 10 channels, capable of performing 400 tests per hour.

Alternative (14) The Technicon SMA 12/60 is a twelve-channel flow-through profile analyzer, capable of 720 tests per hour.

Alternative (15) The Technicon Auto-analyzer II is a dual-channel, flow-through, low-volume instrument used for routine tests. Its modular design allows channels to be added easily.

It can perform 120 tests per hour.

Alternative (16) The Technicon Auto-analyzer II, expanded to three channels, is a flow-through analyzer used to back up profile analyzers. It can complete 180 tests per hour.

Alternative (17) The Dupont ACA is an emergency (fast turn-around) single-channel analyzer capable of 75 tests per hour.

Alternative (18) Centrifi-Chem of Union Carbide is a single-channel kinetic rate analyzer used for enzyme tests. It can perform 120 to 600 tests per hour, depending upon test complexity.

D. Equipment Leasing

Alternative (19) Test equipment used in the current BLHC Systems is almost always purchased outright, an approach which has two basic drawbacks:

1 Equipment purchase is generally justified for a relatively long-term use, i.e., 10 to 20 years and depreciated accordingly. In the clinical laboratory area, particularly, cycles of this length are generally improbable because of rapid equipment obsolescence.

2 More and more research into the automation of clinical laboratory tests is producing rapid introduction of new technology and equipment into entirely new areas.

These factors combine to make purchasing of equipment and training of personnel unattractive thus inhibiting the introduction of new equipment and test procedures or, alternatively, limiting the introduction of these test procedures to manual techniques. As a result, the Study Team evaluated the cost benefit to be gained by leasing or renting equipment which would offer significant operating economies within the clinical laboratories.

Conclusions

1. The selection of equipment within the Clinical Laboratory at a BLHC System is dependent on the test volume per unit of time (generally a

month). Ranking or evaluating alternatives based on gross facility size as distinct from the majority of the other operations categories was not possible. Alternatives were evaluated on the present value method normalized to average rates per month for each department within the Clinical Laboratory.

2. There are distinct and quantifiable scale breakpoints which separate the decision not only to use an automated rather than a manual procedure, but also as to which type of automated equipment, if any, should be used. The State-of-the-Art survey provided sufficient data to establish these differentials.
3. The current method for assessing laboratory workload in terms of Composite Weighted Work Units (CWWU) is inadequate and when compared with actual operating data at the primary BLHC Systems studied in this program, CWWU understates clinical laboratory workload by magnitudes of three to five times.
4. The current accounting and biomedical statistic reporting systems observed at the BLHC Systems were non-uniform between services and generally provided inadequate data for analysis in relation to the origin of the test patient category within the dependent population -- age/sex specific; IP or OP; day of stay in-patient area, and the relationship between disease incidents and type and number of tests requested. All these data are essential to more sophisticated planning projections of future growth.
5. The current criteria used in the facilities design process for determining the degree of automation possible, and assigning space, are inadequate; automating more operations can be cost-justified than these criteria would indicate.
6. There was considerable variation in both equipment and techniques used between BLHC Systems. Many of these differences reflect the preference indicated by individual physicians during the planning design process, even though these specific physicians were often only associated with the facility for a relatively short time.
7. Leasing high cost, highly complex equipment subject to rapid obsolescence is preferable to outright purchase. Studies indicate that there is a justifiable breakpoint for this decision at or near $25,000.

8. Scattered or decentralized clinical laboratories lead to ineffective and inefficient use of manpower and equipment and contributes to the potential for error and delay. Facility designers should be aware of the design implications of a 100 percent increase in the clinical laboratory work load every six years.
9. In a typical BLHCS clinical laboratory, costs per test generally increase as the volume increases, whereas the reverse is normally true for independent civilian laboratories. This disparity should be overcome through more effective scheduling and resource utilization and the ability to rapidly change from manual to automated procedure as volume varies.
10. One of the largest causes of delay and lost time is the use of manual communications between clinical laboratories and many of the other BLHCS areas.

Recommendations

1. The following equipment or procedures should be used in all new BLHC Systems when related to the various workloads indicated below:

Blood Chemistry

Manual Procedures	0 - 750 tests/month
Automated Procedures	
(1) Auto-Analyzer (Single Channel)	750 - 3,000
(2) Centrifi - Chem	3,000 - 11,000 tests/month
(3) DSA 560	11,000 up tests/month

Hematology

Manual Procedures	0 - 1,500 tests/month
Automated Procedures	
(1) Coulter Counter FN	1,500 -11,000 tests/month
(2) Coulter Counter S	11,000 up tests/month

Blood Bank

Manual Procedures	0 -	7,000 tests/month
Automated Procedures		
(1) Technicon	7,000 -	tests/month

2. Present design criteria should be re-evaluated for the purpose of space planning to incorporate more flexibility, less compartmentalization, and more consideration for the dynamics in the growth of the workload.
3. Test procedures and equipment should be standardized. The method of reporting clinical laboratory data should be altered so that more precise internal management can be effected and more usable data generated for the prediction of workloads resulting from given in-patient, out-patient mixes, age/sex groupings, and disease incidences..
4. Wherever workload indicates the need for an automated testing device that has a purchase price in excess of $35,000 it should be leased rather than purchased.
5. Where automated test equipment is purchased, the purchase contract should contain a clause allowing BLHCS personnel to test the equipment for type and volume of workload in that laboratory. This would obviate much of the confusion generated by vague and conflicting manufacturers' claims.
6. Because communications are so critical to the clinical laboratory, equipment which can effect adequate and low-cost image storage and retrieval should be analyzed. This concept should be evaluated even if a computer-based information or data management system is not to be considered for the overall system.

Evaluation Assumptions

1. Laboratory technician wage rate of $3.60/hour (W)
2. Reagents costs are published vendors' prices. (C_i)
3. Leasing costs are 3.4 percent of instrument sales price per month, over 30-month lease period. (L)
4. Average daily test rates by Beaufort and Dix, converted to monthly averages by multiplying by 24 working day/month.

5. Total monthly cost Computed as follows:

$$\sum_{i=i}^{N} \left[V_i \cdot [C_i + T_i \cdot W] \right] + L = \text{Total Monthly Cost}$$

i = each test

N = Number of different tests

V_i = Monthly test volume

C_i = Reagent cost per test (in some cases C_i = Reagent + Labor Cost, then $W = 0$).

T_i = Time per test in hours. (Given by manufacturer's technical personnel, or computed using machine throughput per hour plus set-up time for automation. For manual times, the Chicago Hospital: Council-Clinical Laboratory Study standard times were used.

L = Monthly machine or capital equipment leasing cost

W = Dollars per hour.

6. Physicians test ordering practices are consistent with those at Beaufort and Dix.
7. Tests, as defined by "The American Society of Clinical Pathologists," are used.

Evaluation Criteria

The following criteria were used in the Westinghouse evaluation:

1. Quality of test results -- how accurate are the results and how does increased accuracy affect medical diagnosis?
2. Field test reports -- what have other hospitals reported on the alternative's success or failure?
3. Speed -- how fast can accurate results be available to the physician?
4. Labor -- can a minimum of unskilled labor produce reliable, accurate results?

5. Sample identification -- are mistakes in sample identification minimized?
6. Preparation time -- is sample preparation time minimized and simplified?
7. Maintenance -- is maintenance simple, inexpensive, and available from the manufacturer?
8. Efficiency -- does the alternative utilize all laboratory personnel in the most efficient manner?
9. Errors -- is error potential minimized?
10. Obsolescence -- is the alternative adaptable to new tests and new methods with only minor modifications:
11. Reliable -- is the alternative operationally dependable?
12. Expandable -- can the alternative accommodate demand for new and additional tests?
13. Contamination -- is the possibility for cross contamination minimized?
14. Flexibility -- can traffic patterns, benches, and equipment arrangement be altered to adapt to changing test mix?
15. Reduced floor space -- will the alternative reduce total laboratory floor space and, therefore, initial investment?

Cost Benefit Analysis

The analysis compared automated and manual test procedures based on data from Beaufort Naval Hospital and Walson Army Hospital. Three different areas of laboratory testing were considered: blood chemistry, hematology, and blood bank. Since inflation rates for labor, reagents, and leasing costs will be the same for all alternatives, only first year costs were considered.

Individual tests were evaluated to determine which could be automated by each alternative, expressed as a percentage of the total workload. Manual and automated costs per test were calculated. Costs to manually perform those tests that could not be automated were added to the costs of automated equipment, resulting in total laboratory operating costs, shown on Tables 3.3-14, 15 and 16. From these data cost-volume curves were drawn for the blood

TABLE 3.3-14

BLOOD CHEMISTRY - BEAUFORT

	TOTAL NO. LAB TESTS PER MONTH AUTOMATABLE	EQUIVALENT MANUAL COST/MONTH OF AUTOMATABLE TESTS	PERCENT AUTOMATABLE	AUTOMATED COST/MONTH	AUTOMATED SAVINGS
DSA-[illegible]	1600	[illegible]	72.[illegible]	$15[illegible]	[illegible]
HYCEL	[illegible]	[illegible]	[illegible]	1,07	- $[illegible].12
SMA [illegible]	[illegible]	87[illegible]	[illegible]	[illegible]	- [illegible]84
DUPONT ACA	1579	[illegible]	[illegible]	[illegible]	[illegible]
CENTRIFI-CHEM	[illegible]	[illegible]	[illegible]	[illegible]	- [illegible]
AUTO-ANALYZER (Single)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
AUTO-ANALYZER (Dual)	[illegible]	[illegible]	30.[illegible]	71[illegible]	[illegible]

TABLE 3.3-15

BLOOD CHEMISTRY - DIX

	TOTAL NO. LAB TESTS PER MONTH AUTOMATABLE	EQUIVALENT MANUAL COST/MONTH OF AUTOMATABLE TESTS	PERCENT AUTOMATABLE	AUTOMATED COST/MONTH	AUTOMATED SAVINGS	
DSA-560	8146	4803	81.9	$2242	+$2561	
HYCEL	7101	4195	71.4	5037	+ 11[illegible]	
SMA 12/60	8071	4516	81.1	3874	+ 642	
DUPONT ACA	7568	3649	76.0	8156	- 4507	
CENTRIFI-CHEM*	6670	3969	67.0	1113	+ 2826	*3326
AUTO-ANALYZER (Single)	3027	1526	30.4	231	- 1292	
AUTO-ANALYZER (Dual Channel)	3027	1526	30.4	861	+ 662	

Total Volume - 9950
Cost Benefit Analysis - Clinical Laboratory - Chemistry

* Centrifuge Capability

TABLE 3.3-16

HEMATOLOGY AND BLOOD BANK FOR BEAUFORT

	TOTAL NO. LAB TESTS PER MONTH AUTOMATABLE	EQUIVALENT MANUAL COST/MONTH OF AUTOMATABLE TESTS	PERCENT AUTOMATABLE	AUTOMATED COST/MONTH	AUTOMATED SAVINGS
Hematology					
Coulter FN	578	$ 186	27.0	$ 217.	-$ 31
Coulter Model S	2178	520	81.7	888.	- 368
Blood Bank					
Technicon Cell Type	6980	2413	90.1	2399.	+ 14
DIX					
Hematology					
Coulter FN	4163	1336	28.4	553	+ 783
Coulter Model S	8449	1774	53.5	1016	+ 758
Blood Bank					
Technicon Cell Type	11008	1683	96.6	3133	+ 1550

chemistry, hematology and blood banking department (Figs. 3.3-27, 28, and 29).

Blood Chemistry and Hematology cost analyses are relatively sensitive to errors in estimating the cost of manual tests. Table 3.3-17 gives total cost of alternatives, including necessary manual costs. The results of increasing manual costs by 20 percent is shown in Table 3.3-18.

Alternatives were evaluated against all evaluation criteria; results, plus cost data, are shown on Table 3.3-19

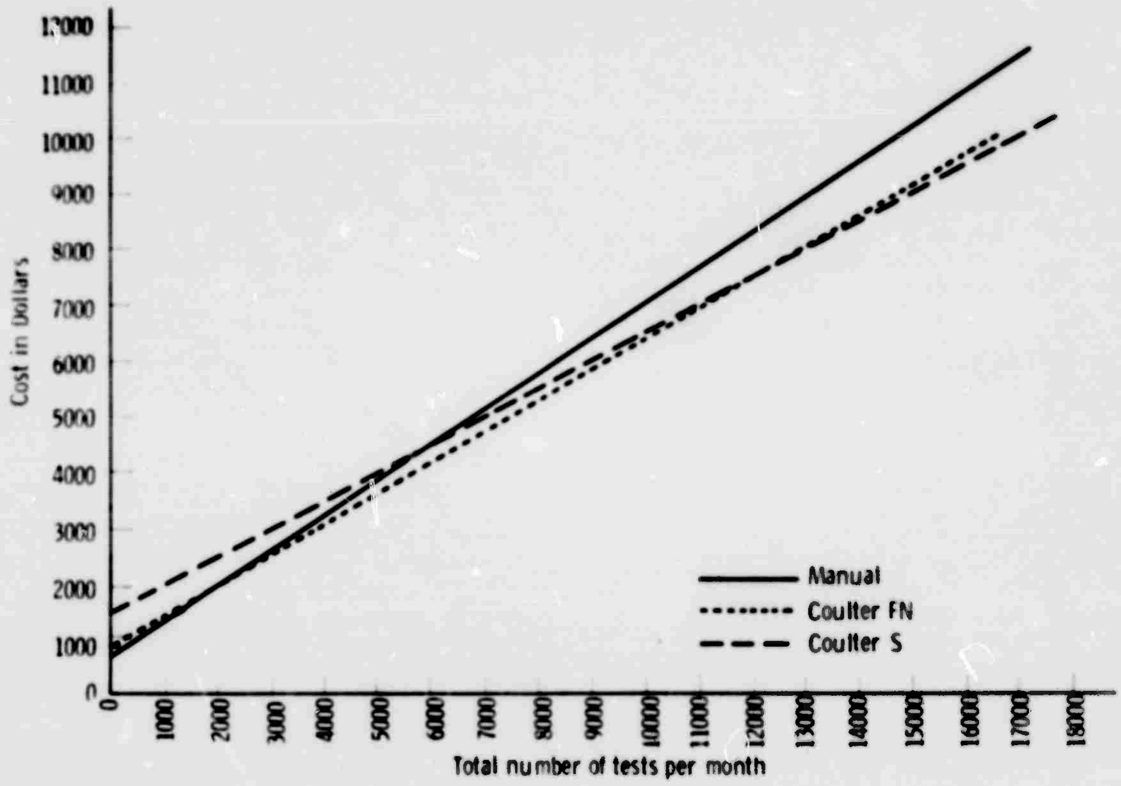


Fig. 3.3-27 —Hematology

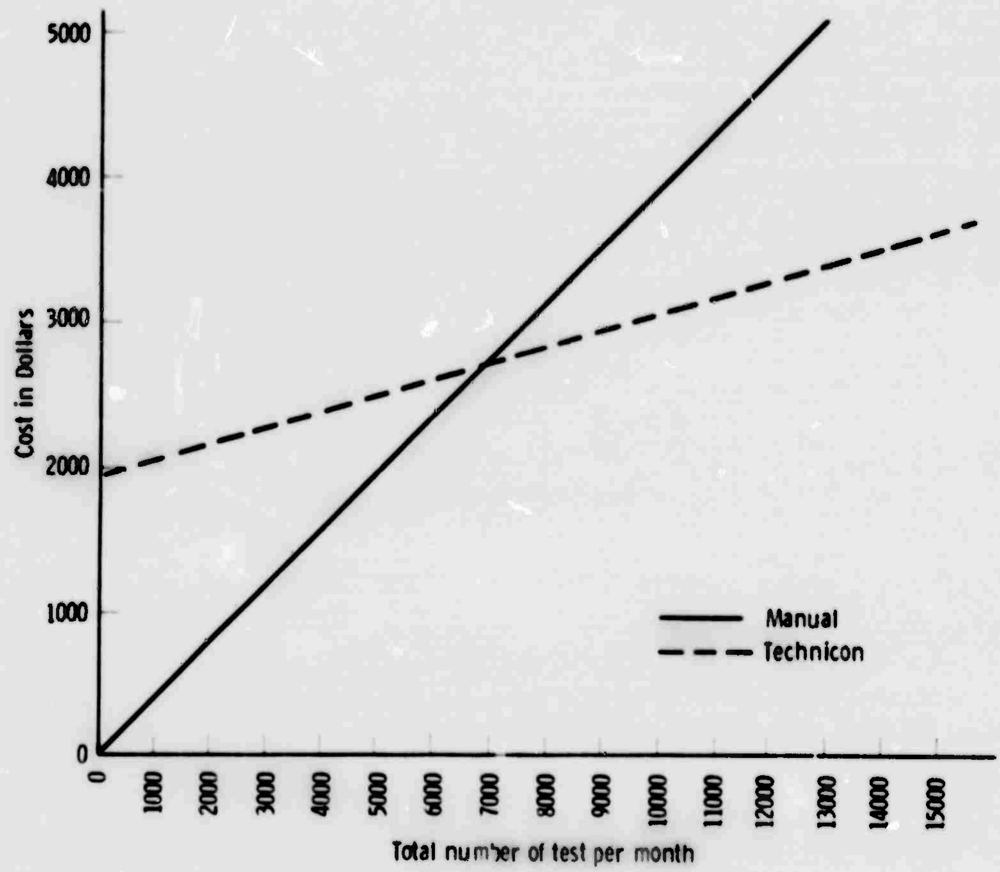


Fig. 3.3-28 —Blood bank

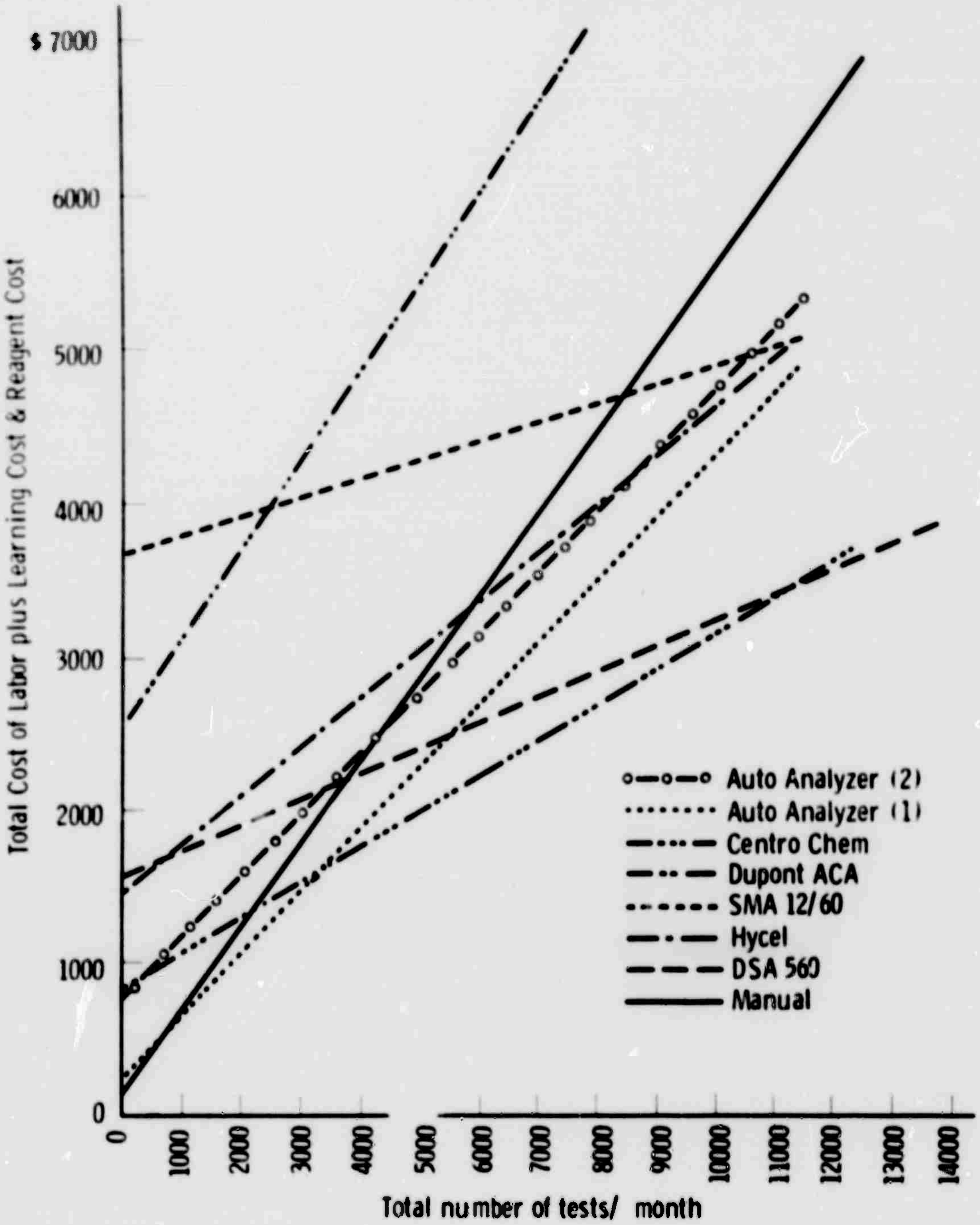


Fig. 3.3-29 —Blood chemistry

TABLE 3.3-17

RANK OF ALTERNATIVES
Cost of Manual Test Increased 20%

	Beaufort		Dix	
	As Estimated	20% Manual Error	As Estimated	20% Manual Error
Chemistry				
Manual	2	1	7	7
DSA-560	5	5	2	1
Hycel	6	6	4	4
SMA 12/60	8	8	6	5
Du Pont ACA	7	7	8	8
Centrifi-Chem	3	3	1	2
Auto-Analyzer Single	1	1	3	6
Auto-Analyzer Dual	1	2	5	5
Hematology				
Coulter FN	1	2	2	3
Coulter S	3	3	1	2
Manual	2	1	3	4

TABLE 3.3-18

TOTAL COST OF ALTERNATIVE: COST OF MANUAL TESTS UNDERSTATED BY [illegible]

	Beaufort	Dix
Chemistry		
DSA-560	$2030	$ 3165
Hycel	[illegible]	4969
SMA 12/60	[illegible]	5151
Du Pont ACA	[illegible]	9777
Centrifichem	[illegible]	3566
Auto-Analyzer Single	[illegible]	5567
Auto-Analyzer Dual	[illegible]	1937
Hematology		
Coulter FN	[illegible]	11632
Coulter S	[illegible]	$11325

TABLE 3.3-19 - CLINICAL LABORATORY ALTERNATIVES EVALUATION

DENTISTRY

Dental care consumes approximately 15 percent of the total operating budget of a typical BLHC System, and personnel costs account for 90 percent of all dental costs. Any improvement to the dentistry function, therefore, must focus on reducing cost per procedure by increasing personnel efficiency and/or patient throughput.

Detailed work sampling studies were performed at three dental clinics; two at Dix and one at Beaufort. All three clinics provide scheduled dental care to recruits and active duty military personnel. The Marine Corps Air Station (MCAS) at Beaufort also provides limited treatment for retirees and dependents.

Present military dental practices vary in methods and in the ratio of dentists to assistants to operatories. The following arrangements were observed:

1. Stand-up dentistry, one assistant, one operatory.
2. Stand-up dentistry, one assistant, two operatories.
3. Sit-down, one assistant, one operatory.
4. Sit-down, one assistant, two operatories.
5. Four-handed, one assistant, one operatory.
6. Four-handed, one assistant, two operatories.

Stand-up dentistry in which the slightly reclining patient is worked on by a standing dentist, usually with one assistant and one operatory, is most common, although the position of operatory equipment often prevents effective use of the assistant. Sit-down dentistry allows a seated dentist to work on a supine patient. This reduces the dentist's fatigue and provides unimpaired work space. Four-handed dentistry, the natural extension of sit-down dentistry, extends the duties of assistants to providing instruments and performing some routine tasks, thereby allowing the dentist to concentrate on the special dental operations.

The physical layout at the Mills Clinic at Dix and the MCAS at Beaufort allows for one operatory per room, with some rooms having connecting doors. The Mills clinic also has a complete dental laboratory. In Dental Clinic #3 at

Fort Dix, 14 operatories are located in a large, partitionless room. Specialty areas have two operatories per room.

Work loads at all clinics are about equal despite differences in population base. Results of detailed studies at the two Dix clinics are illustrated in Figures 3.3-30, 31, 32 and 33. Some pertinent conclusions are:

1. Personnel Utilization
   - Patient workload in the two clinics shows comparable curves in the morning, but vary considerably in the afternoon. Clinic #3 peaks at 55 percent of total activity between 0900 and 1100 hours (as opposed to 45 percent for Mills), dropping to 40 percent between 1100 and 1200 hours. In the afternoon, the Mills clinic shows a high level of work activity between 1300 and 1400 hours (64 percent), then drops sharply to about 40 percent between 1600 and 1700. Clinic #3 starts the afternoon at 55 percent and slowly declines to 50 percent.
   - Non-productive time peaks just before lunch in both clinics, and again between 1600 and 1700 hours.
2. Personnel spend about 75 percent of their time in the operatories in both clinics.

The Westinghouse study of three dental clinics is detailed in the data inventory volume.

Technical Approach

The technical approach used was basically the six step procedure outlined on pages 3.3-4 through 3.3-11 of this volume. The present system was detailed by observation and interviews by study team members and our dental consultants. Based on this the problems were delineated and solutions proposed based on the SOA study and the dental consultants. The various alternatives were evaluated on both a cost basis and subjectively. Sensitivity analysis was also performed and from these last steps the final recommendation determined.

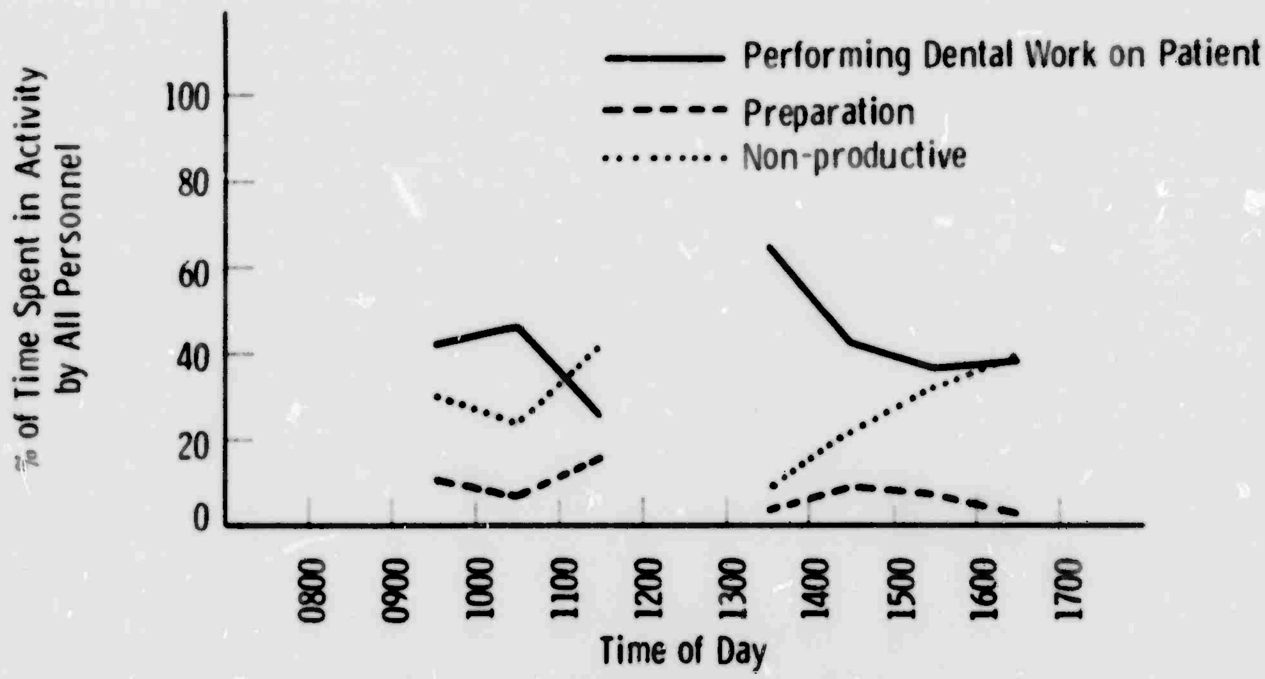


Fig. 3.3-30 —Personnel utilization—Mills Dental Clinic

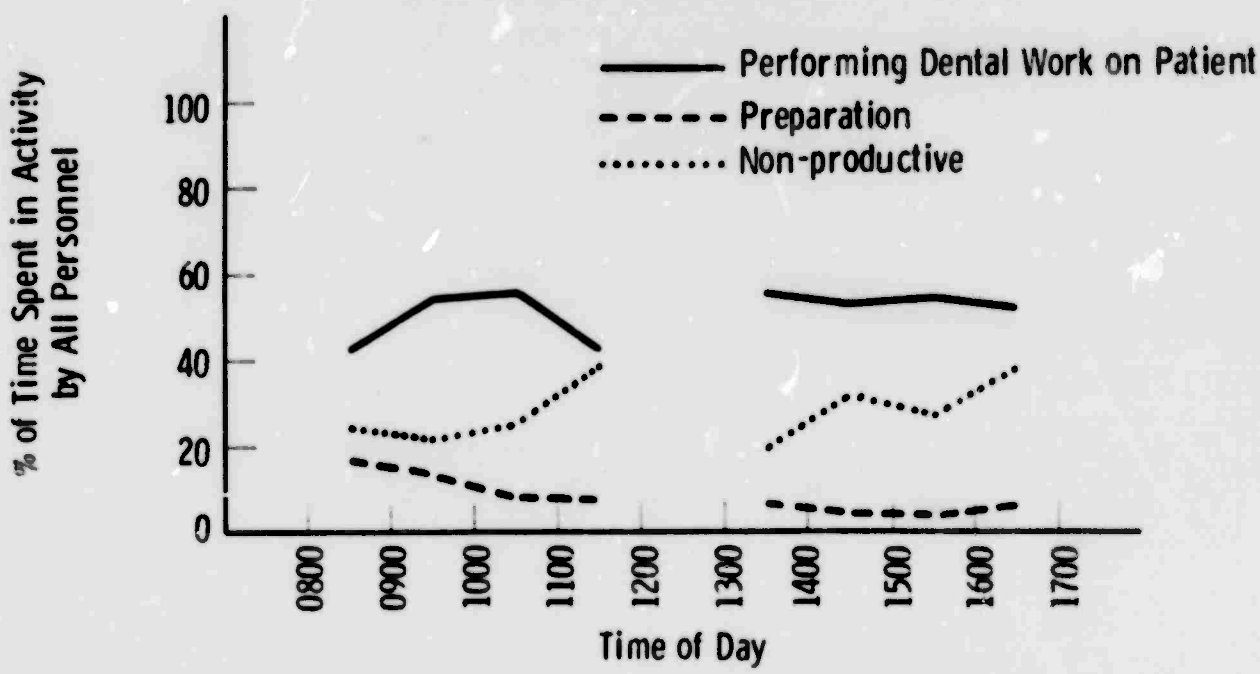


Fig. 3.3-31 —Personnel utilization— Dental Clinic #3

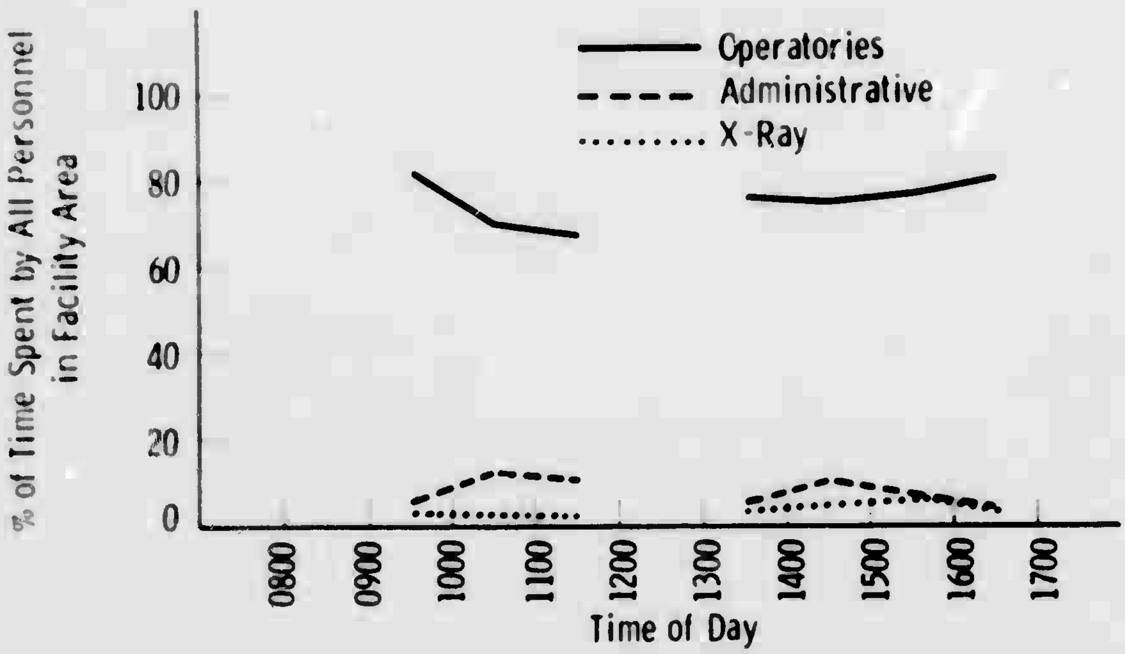


Fig. 3.3-32 —Personnel location—Mills Dental Clinic

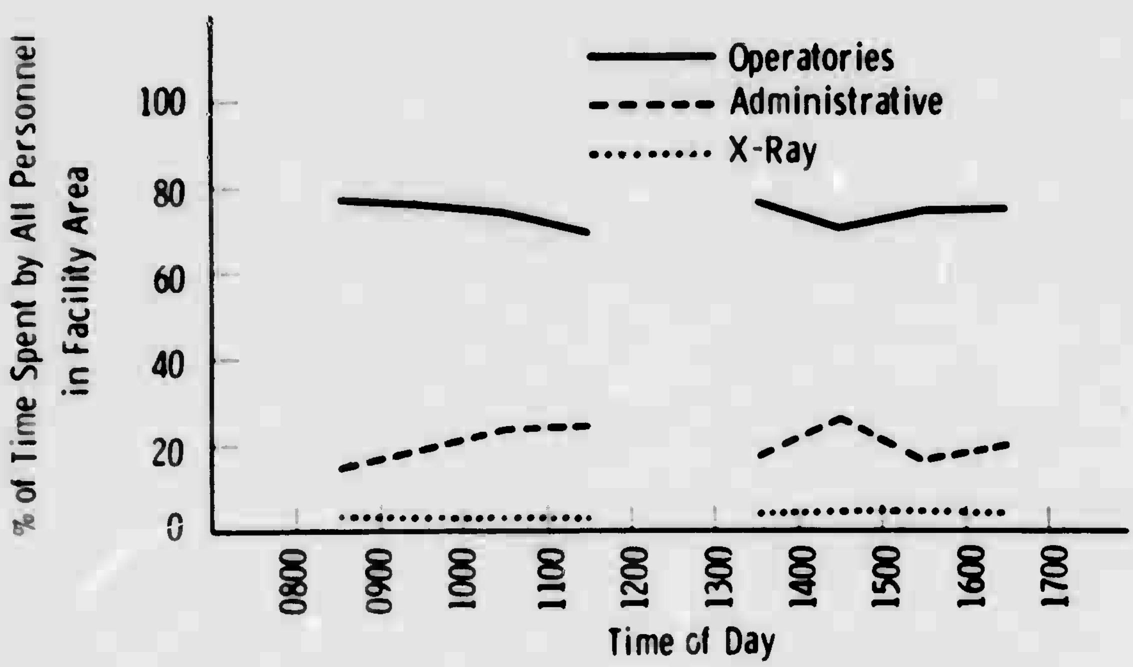


Fig. 3.3-33 —Personnel location—Dental Clinic #3

Improvement Alternatives

Ten improvement alternatives were evaluated for cost/benefit and for their ability to meet our evaluation criteria. These alternatives can be separated into three general categories: the ratio of dentist to operatories to assistants, dental procedures, and facility layout.

1. The ratio of dentists to operatories to assistants has five improvement alternatives:

Alternative	# Dentists	# Operatories	# Assistants
1	1	1	1
2	1	1	2
3	1	2	3
4	1	3	4
5	1	4	4

2. Dental procedures include:
   6. Two-handed dentistry, where the dentist works essentially by himself or with limited assistance.
   7. Four-handed dentistry, where the dentist uses capable assistants for routine work and for handing him tools and instruments.
3. Facility layout alternatives include:
   8. Individual rooms (Figure 3.3-34)
   9. Rectangular multiple-operating design. (Figure 3.3-35)
   10. Circular cluster (Figure 3.3-36)

Conclusions

1. Dentistry, however it is practiced, is labor-intensive with approximately 90 percent of all dental costs being personnel costs.
2. Current military practice under-utilizes the higher skill categories (dentists). The productivity of these individuals could be increased more than 40 percent overall through revised work practices and through the use of assistants.

Studies indicate that 27 percent of the total procedures are "operatory" in nature and is amenable to significant improvement in terms of time savings. The remainder -- oral diagnosis, treatment planning, oral surgery, and oral hygiene -- does not presently show the same potential. Since the so-called "operating procedures are in general far more time consuming than the other procedures, the investment of total personnel resources in this category will exceed 27 percent.

3. Of all proposed changes in operatory practice considered, sit-down four-handed dentistry seemed most efficient.

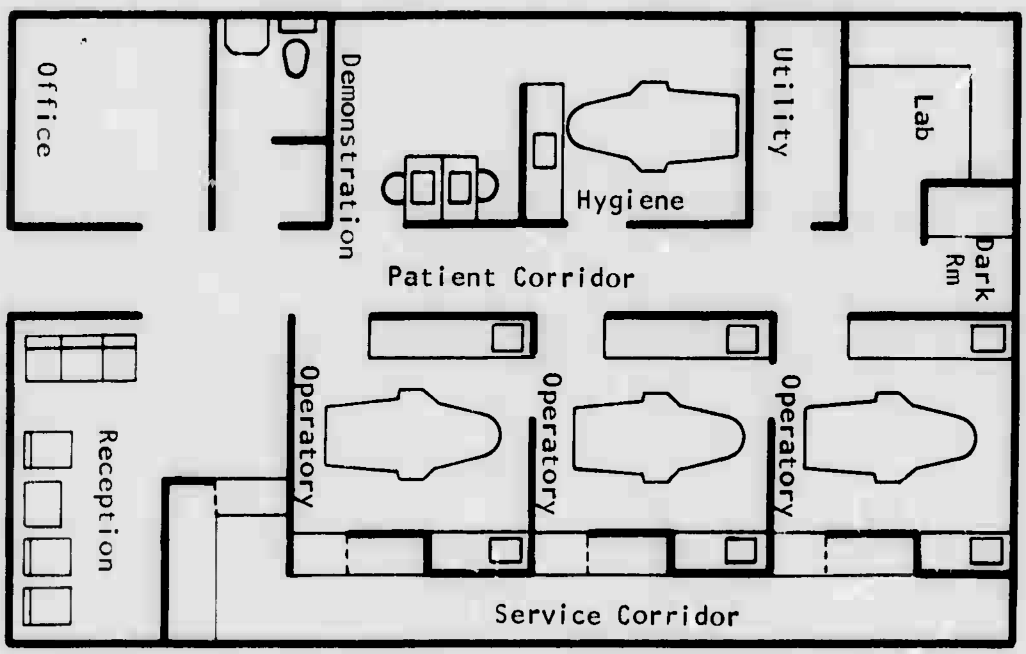


Fig. 3.3-34—Dental facility improvement layout - individual rooms

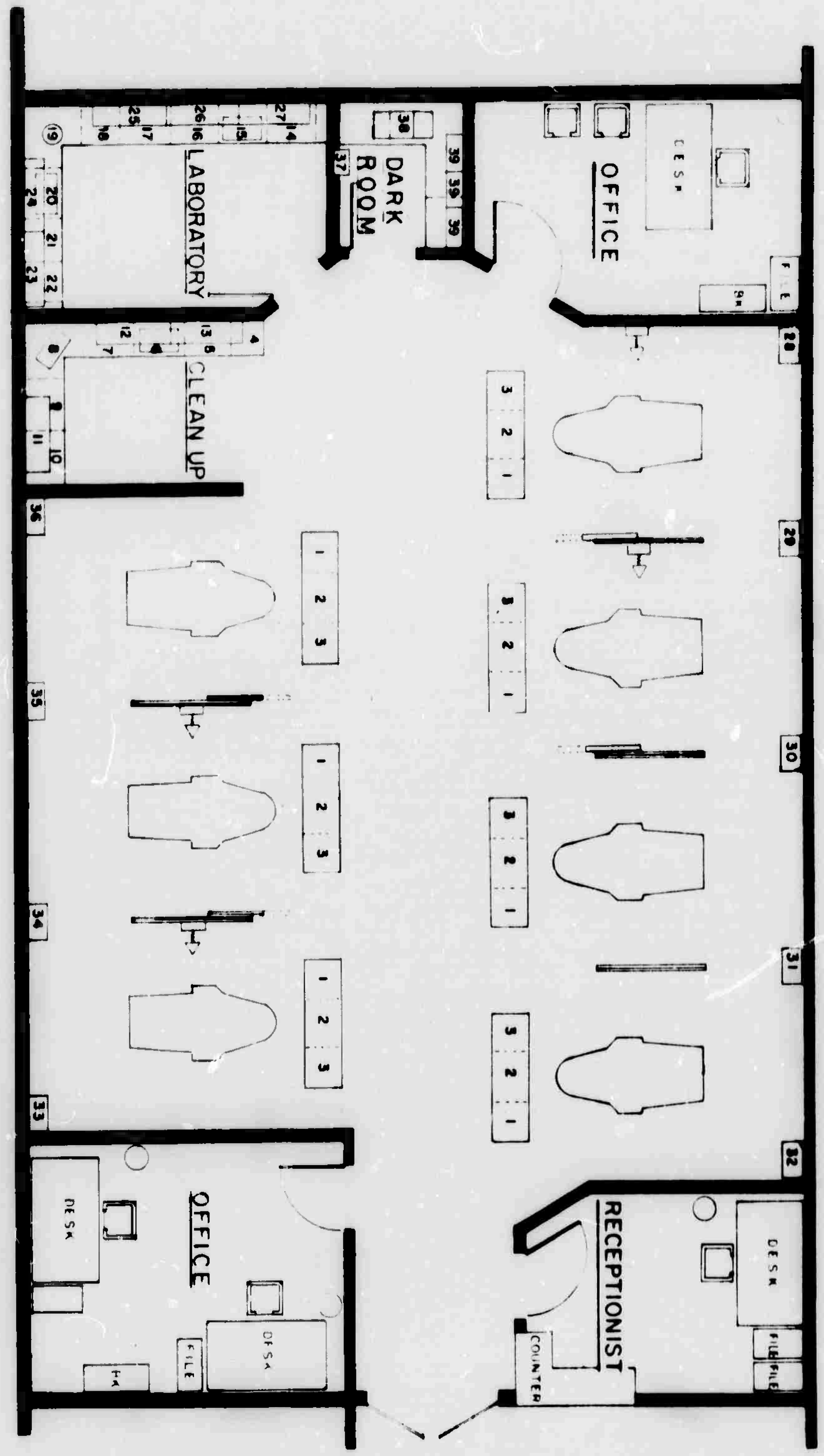


FIGURE 3.3-35 RECTANGULAR MULTIPLE-OPERATORY DESIGN WITH SLIDING PARTITIONS

Figure 3.3-36 Circular Multiple-Operatory Design

4. The average dentist, using a higher level of technical assistance and four-handed sit-down procedures, should be able to handle three operatories without personal fatigue or loss of quality. Any attempt to improve utilization beyond this point should be related to individual capability.

5. The current facility planning embodying many small, individual rooms is inefficient and should be replaced with a rectangular arrangement for the majority of operating procedures.

Recommendations

The Westinghouse Study Team recommends that:

1. For new facilities, new design criteria should be developed to allow for use of the rectangular layout for most operatory procedures. Procedures not recommended for bull-pen and which should be done in separate rooms are: oral surgery, periodontics and endodontics.

2. Staffing criteria should be utilized to allow a ratio of one dentist to four assistants to three operatories.

3. As equipment and training permits, four-handed sit-down dentistry should be practiced.

4. Intensive industrial engineering studies should be undertaken to develop new facility layouts and procedures to improve the approximately 73 percent of the total workload which is unaffected by the above recommendations.

5. Increase the emphasis in the current preventive dental program in such areas as dental prophylaxis, fluoride treatments, water-supply fluoridation, and patient education on prevention of dental disorders. Dental hygienists, rather than dentists, could conduct the program.

6. DoD should consider standardizing all dental clinic procedures for existing facilities and considerable attention should be given to introducing the above operating procedures even where existing facilities do not have the same layout advantages as the bull-pen approach.

Evaluation Assumptions

1. Personnel cost (including 20 percent of base pay for fringe benefits): \$14,400/year for class O3 dentist and \$5,520/year for class E4 assistants.
2. Personnel work 48 weeks/year at 37.5 hours/week.
3. Twenty-seven percent of the total dental workload can be done using the one dentist to three operatories to four assistants ratio (based on a review at Fort Dix of the detailed categories of dental procedures by the Westinghouse dental consultant). The remaining 76 percent of the work is oral diagnosis, treatment planning, oral surgery, and oral hygiene, activities which are not applicable to the recommended ratio.
4. Navy Report of Clinical Tests MR 005.12 - 5004.13 applies to all military dental clinics.

Evaluation Criteria

Separate criteria were used to evaluate each category of alternatives. The ratio of dentists to operatories to assistants was evaluated on:

1. Cost - cost per procedure and personnel costs.
2. Patient throughput or the number of procedures that can be done by a dentist in an hour.
3. A subjective evaluation of the quality of the dental work.

The two procedural alternatives were evaluated on the basis of efficiency in terms of utilization of the dentists time.

The layout alternatives were evaluated according to the following subjective criteria:

1. Dentist Efficiency - is the dentist fully utilized, can he maximize his patient throughput without impairing the quality of his dentistry?
2. Administrative Control - can the clinic Commanding Officer maintain control over the personnel working in the clinic?

3. Ease the Expansion - how readily can additional operatories be added as the workload increases?
4. Cost of Expansion - the relative cost of adding additional operatories.
5. Total Personnel Utilization - how well are dentists, assistants, hygienists, and X-ray technicians utilized?

Cost Benefit Analysis

Ratio of Dentists to Operatories to Assistants:

Using the data gathered from Fort Dix, the number of restorations per hour per dentists and the personnel cost per procedure were determined on the basis of one dentist to one operatory to one assistant. Applying the results from Navy Report MR 005.12 - 5004.13 to this data yielded Table 3.3-20. Although reporting of procedures varies between services, the percentage of workload in the various categories is comparable, i.e., 27%.

TABLE 3.3-20

Ratio of Dentists to Operatories to Assistants in Terms of Treatment Costs

# Dentists	# Operatories	# Assistants	Restorations per Hour	Cost per Procedure
1	1	1	1.25	$9.05
1	1	2	1.66	8.70
1	2	3	4.10	4.29
1	3	4	5.56	3.72
1	4	4	6.26	3.31

Personnel cost per procedure shows a decline from the present $9.05 to $3.31 when one dentist has four operatories and four assistants. Conversely the number of restorations per hour increases from 1.25 to 6.26.

Since supplies, equipment, and maintenance are the same in all these alternatives, the only cost considered in the Present Value Life Cycle Cost is personnel cost. Using the data from Table 3.3-20 together with a 4 percent inflation rate and a 10 percent discount rate for money, the present value

20-year life cycle cost was calculated and plotted against Total Annual procedures for each alternative (Figure 3.3-37).

Fig. 3.3-39 shows that errors in estimating the number of procedures has little effect on the rankings of alternatives. Moreover, changes in inflation and discount rates as well as inaccuracies in percentage in the number of patients treated per hour are also relatively insensitive. The overall effectiveness of each alternative, as shown by its percent increase in the number of procedures per hour over the preceding alternative, is shown in Table 3.3-21.

TABLE 3.3-21

Alternative			% Increase in Procedures per Hour over Preceding Alternative
Dentists	Operatories	Assistants	
1	1	1	-
1	1	2	33%
1	2	3	147%
1	3	4	35%
1	4	4	13%

Although the one dentist to four operatories to four assistants has the lowest cost, it is not the recommended alternative since the Navy reports that the four chair system taxes the energies of the dentist officers to the extent that the quality of their work deteriorates.

Dental Procedures

At the present time, all schools of dentistry have federally supported programs to teach four-handed sit-down dentistry. It is a far more efficient system in terms of utilization of the dentist's time than is two-handed dentistry. Dental assistants and dental students are being trained to pass instruments from one to another in a most efficient manner so that it is not necessary for the dentist to leave the immediate area of the mouth to complete the operation.

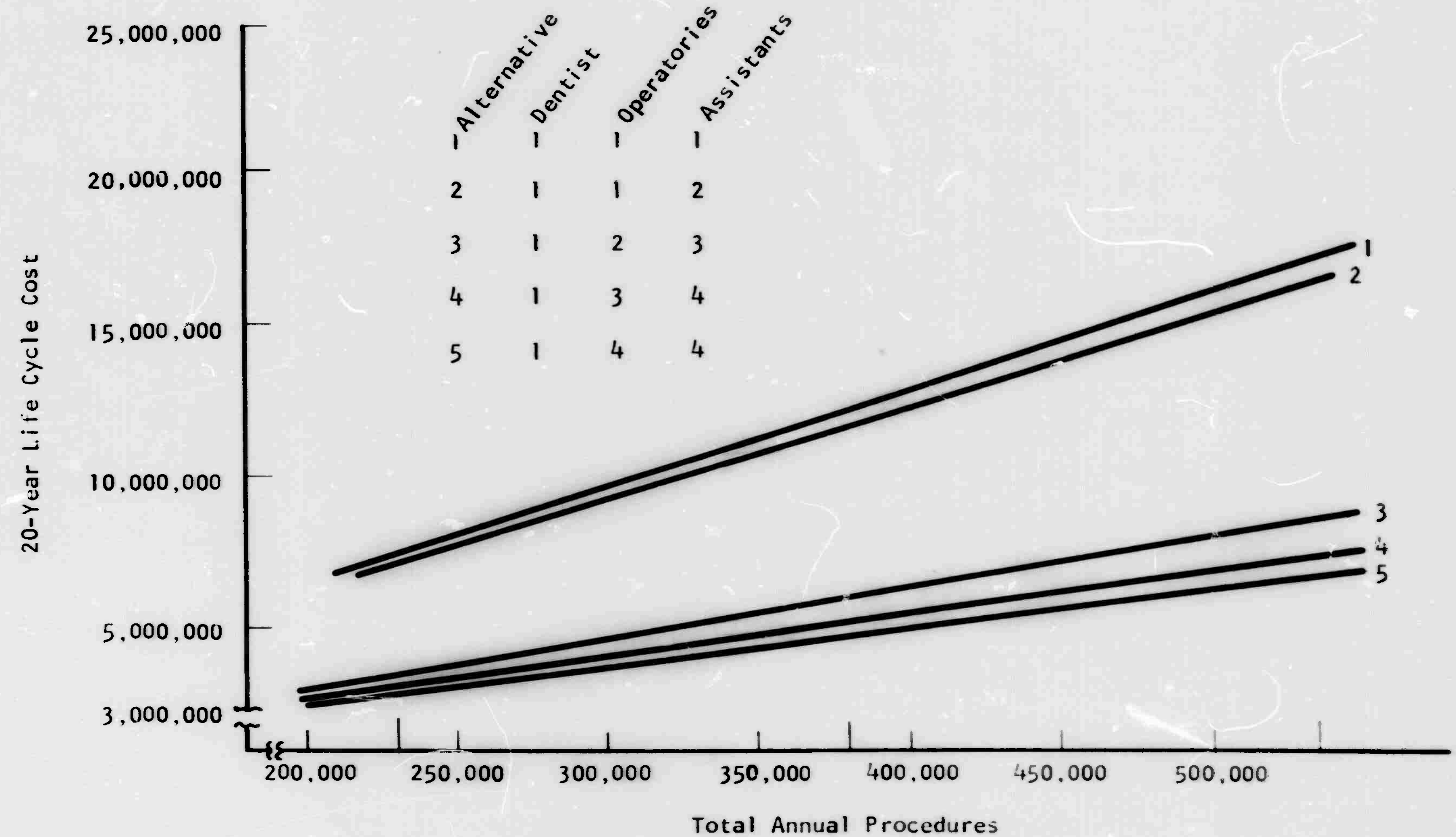


Fig. 3.3-37 —Twenty year life cycle costs for dentistry inprovement alternatives

Facility Layout

The three alternative layouts were evaluated subjectively on the five criteria mentioned above and the results are tabulated in Table 3.3-22.

TABLE 3.3-22

	Dentist Efficiency	Administrative Control	Ease of Expansion	Cost of Expansion	Total Personnel Utilization	Patient Environment
Individual Room	1	1	3	2	1	3
Rectangular Multiple Operatory	3	3	3	3	3	1
Circular Cluster	3	2	1	1	2	1

Ratings based on a 1 to 3 scale with 1 being lowest and 3 being highest. The individual room layout received one high and three low ratings: and the circular cluster had one high and two low ratings. The average ratings are:

Individual Room	1.8
Rectangular Multiple Operatory	2,6
Circular Cluster	1.6

OUTPATIENT DEPARTMENT

Introduction

Outpatient Department (OPD) activities are one of the most labor intensive in the BLHC System with approximately 85 percent of the cost being personnel costs. Superficially, there was little relation between the three primary BLHC Systems studied -- the percentage total operating budget represented by the OPD function range from 3 percent to 36 percent at the three Systems studied; cost per patient visit varies widely; and there are considerable differences in the staff specialty mixes which tends to influence the apparent health care demand statistics. All three Systems, however, have several basic similarities -- a faster growing workload in the OPD than in any other area; almost every department of the OPD is saturated; scheduling systems, when available, are generally improperly used; professionals are overburdened with administrative work; poor staff and patient traffic patterns detract from efficient patient processing; and poor flow of data and communications between OPD clinics, records, ancillary services and the inpatient areas. Another characteristic was that physicians operating in the OPD area were generally allowed to establish offices and adjacent examining rooms as their personal territories. In many cases this was their only office space and became their retreat for activities such as administrative duties; and education and research; as well as private activities. Thus, while more and more space is being demanded, large portions of existing OPD space stand idle while their occupants are on rounds or otherwise engaged. The lack of space is further compounded by the assignment of space to specialty clinics which only operate on certain days; during the remainder of the time these facilities stand idle.

Improvement Alternatives

It is extremely difficult to select or to analyze operational improvement alternatives that will have an effect on the OPD as a whole. Some of the alternatives selected for the study then, are not amenable to quantification and comparison for the present value method for cost justification. In addition, the major improvement is inextricably interrelated to a more effective management of resources based on

an improved data communication system (see Communications and Data Management). The second most important improvement is related to better facility design logic incorporating better traffic patterns and discrete clinics with rapid and logical growth capabilities tied to better demand forecasting.

There are, however, five areas which were isolated for evaluation and analysis:

(1) The training and extensive use of highly trained Physicians Assistants to relieve the physician of the bulk of his present administrative functions and increase his effectiveness.

(2) Automated Multiphasic Testing to rapidly provide the physician with more, highly accurate physiologic data.

(3) Multiple use of facilities to better utilize hospital space and equipment and to permit longer hours of operation in the OPD.

(4) Increased number of examining rooms per physician to increase the physician's throughput capability.

(5) The introduction of outpatient surgery (Surgicenter) to reduce costs for minor surgical procedures.

Conclusions

(1) There are a number of functions which physicians now perform in the BLHC System which can be performed by an adequately trained Physician's Assistant without lowering the quality of health care. Generally, these activities are of an administrative and technical nature and do not require extensive medical knowledge. Use of these assistants would free approximately 20 percent of the physician's time for more productive medical care activities in this manner.

(2) It is practical to develop and maintain adequate education and training programs within the DoD to produce Physician's Assistants.

(3) Most outpatient clinics should be used for twelve hours/day five days/week for greater utilization of facilities. To accomplish this would require revision to the planning concepts embodied in the current

space criteria. The major elements of these changes would be related to the use of facilities by different people and possibly for different specialties over the course of a week. The nature of most clinic facilities, therefore, will need to be reexamined and facilities which are permanently assigned to individuals (such as offices) will need to be relocated.

(4) Most clinic practice is such that physician's time can be more effectively used if he is allocated more than one examining room. This analysis has justified the use of at least two such rooms per physician. While more rooms per physician may be justified for some clinics, this would lead to more specialized facility layouts.

(5) Scheduling of patients to clinics -- both inpatients and outpatients -- is a management tool which is not used to its full potential in the existing system.

Recommendations

(1) The Physician's Assistant concept should be adopted for all outpatient clinics in new BLHC Systems. Appropriate education and training programs should be created for developing such personnel based on an assessment of the scope and nature of the activities which can be displaced from the physician to his assistant.

(2) Staffing and programming criteria should be reviewed to establish the changes required (if any) to implement the Physician Assistant concept.

(3) If no change is required to the space criteria to implement alternative number 2, a study should be initiated to consider the introduction of this concept throughout the existing BLHC Systems.

(4) The staffing and space planning criteria for outpatient clinics should be reevaluated and revised to allow for those alternative operational procedures which have been shown to produce more effective use of facilities and personnel.

These studies should be directed at planning and design criteria which will allow for:

(a) Operation of most clinics twelve hours/day for five days/week.

(b) Provision of two examining rooms per physician for most clinics.

(c) Provision of suitable office space for physicians outside the clinic so that facilities can be used by more than one physician (or specialty if necessary).

(5) The study required for the above recommendation should be integrated with a broader study of the design logic to be used in outpatient facilities as outlined in the design section of this report.

(6) The concept of "outpatient surgery" is both practical and can be cost justified for new BLHC Systems. The concept, however, is best introduced as an integral part of the composite facility -- utilizing the existing operating room suites; personnel and ancillary services as distinct from a separate facility and staff.

(7) The costs and benefits to be gained by introducing automated multiphasic screening are not sufficiently defined or cost justifiable to recommend this approach for the BLHC System in general at this time.

Analysis of Improvement Alternatives

Alternative 1. Physician Assistants

A comprehensive analysis of the data obtained at the three primary BLHC Systems provided the study team with a listing of the physician's duties in each of the outpatient clinics and an assessment of the amount of time required for each of these activities. The nature of each of these activity groups, the level of skill required, and the role it played in the diagnostic and therapeutic processes was established. From these data those activities which could be appropriately performed by competent nonmedical personnel and the associated savings were established.

The conclusions concerning the potential for transferring activities to Physician's Assistants were carefully evaluated by medical experts to ensure

these proposals would not lower the quality of patient care. The state-of-the-art survey was then reviewed to establish whether similar proposals were being implemented in other health care systems and what, if any, difficulties were to be expected in training and using military personnel in this manner. This alternative appeared viable from all these viewpoints.

A cost analysis was then performed using the following assumptions:

- At least 20 percent of the physician's time be freed using this alternative.
- At least 50 percent of the cost of an average outpatient clinic visit represents physician time cost.
- The average outpatient clinic visit cost is \$4.91.
- The personnel cost for a physician's assistant is 25 percent less than for a physician.

The cost savings per visit was calculated as follows:

$$(\$4.91 \times 0.5) \times (0.2) \times (0.25) = \$0.12/\text{visit}$$

For the range of BLHC Systems covered by this study the annual expected savings are as follows:

Number Outpatient Visits/Year	Annual Cost Savings 1970 Values
300,000 outpatient	\$36,000
450,000 outpatient	\$53,000
650,000 outpatient	\$78,000

Although the cost required to train personnel as physicians' assistants was not deducted from these savings, the above assumptions are relatively conservative and Westinghouse estimates the use of this alternative is at least a breakeven proposition and therefore cost justifiable. The cost savings will increase over time as personnel costs escalate.

Alternative 2. Automated Multiphasic Testing

This alternative relates to a generic grouping rather than a specific single hardware item or management procedure and as such there is considerable variation in understanding its objectives, methods and scope of procedures.

This alternative has been classified as acombination of automated clinical laboratory procedures and manual testing coupled with a dedicated BLHC System computer designed to conduct in a single 2-hour visit an extremely broad array of tests. This generates an adequate physiological profile for patient review and consultation at the end of that time span.

The major objective of multiphasic testing is to review large numbers of apparently well people with a high degree of accuracy and at low cost. It is largely a preventive medicine tool in that early indications of abnormality can be detected and treated. This procedure is also intended to generate more data at less cost than would be incurred if each of the tasks were performed separately.

Advocates of this alternative argue that its advantages are:

(1) Better patient data profiles, even when obtained on apparently well people, are an aid to the diagnostic process.

(2) Early detection of diseases will result in less costly treatment and probably lower mortality rates.

(3) That economies of scale exist which will bring the cost for each individual down to an acceptable level.

The Westinghouse review of this alternative indicates that multiphasic testing may have definite value to the military for pre-induction, periodic, and discharge physicals for active-duty personnel, as well as a preventive medicine program for the dependent population. The software and equipment is so complex, however, that there is some dispute as to what tests should be done. Also, the costs for performing a complete multiphasic testing program cannot be reduced below a cost which is 4 to 5 times the cost of present physicals. Thus, there is little or no basis for recommending this procedure. In addition, the little evidence which does exist regarding the early detection capability and economies of early treatment are inconclusive and not substantive enough to argue for its introduction.

Alternative 3. Multiple Use of Facilities

Multiple use of facilities extends space and equipment use beyond the normal daylight working hours. Ambulatory facilities in the BLHC System are typically overcrowded between 9 a.m. and 5 p.m. After 5 p.m. all clinics, except the emergency room, close until 9 a.m. the next morning.

The trend in civilian hospitals to extend clinic hours beyond 5 p.m. is applicable to military systems. For example, induction, periodic, and discharge physicals are all presently done between 9 a.m. and 5 p.m. By moving these physicals to 6 to 10 p.m., all laboratory tests such as blood, urine, X-ray, vision, audiogram, EKG, spectrometry, and dental care could be completed in two hours per patient, leaving ample time for physician review prior to patient examination.

Also, periodic physicals require active duty personnel to be away from work for an average of 4 hours, a loss of productive time which could be eliminated if physicals were given after working hours. For example, in a system where 12,000 physicals are given each year (45 per working day), assuming 2 hours per examination, $9,000 average annual pay, 4 percent labor escalation, 20 percent fringe benefits, and 10 percent discount rate, that system could save $233,000 (present value dollars) over the 25-year life cycle. Benefits which accrue through multiple use of facilities include:

(a) Pediatric and pre-natal care and family planning programs will be more available during the 6 to 10 shift, therefore, mothers and children can most readily avail themselves of the services.

(b) By increasing operating time from 7 to 12 hours per day, facilities will be available 71 percent more time and space requirements will be reduced by 31 percent. A system planned to provide 100 physicals per 7 hour shift needs 3,500 square feet; on the basis of a 12 hour operation, the same number of patients could be processed in 2,250 square feet, reducing initial investment by $37,500 (1250 square feet at $30 per square foot).

Alternative 4. More Examining Rooms per Physician

The number of examining room per physician is typ8cally a one-to-one ratio in existing BLHC Systems. Exceptions include:

Type of Practice	Number of Examining Rooms / Physician
General Practice, Unscheduled	2
Surgical	
Orthopedic	2
Plastic	2
EENT, Otorhinolaryngology	2
Pediatrics	2
OB-GYN	2
Physical Examination	2

Physicians in the BLHC Systems studied consistently complained about the lack of examining rooms, a condition resulting from two causes:

(1) As breadth of demand for outpatient services increased, specialties which had been allocated two rooms were reduced to one to accommodate additional specialties; staff, however, was increased.

(2) Current space criteria (DoD 6015.7, 18 December 68) does not allocate two examination rooms to any clinics which have more than a 20 minute per visit schedule.

Outpatient costs can be significantly reduced by assigning two examination rooms per physician in all clinics, if possible. Table 3.3-23 was developed based on the following assumptions:

(1) Fifty percent of patient visits are being performed by physicians using two examination rooms.

(2) Twenty-five percent of the remaining patient visits can be performed by physicians using two examination rooms.

(3) Physicians time is valued at 17¢/minute or $20,000/year.

(4) Number of examination rooms available will not increase directly due to reduction in exam time and, therefore, will increase patient throughput.

(5) Examination room space costs $30/square foot.

(6) All costs and savings are expressed in present value dollars.

(7) The number of outpatient visits per year is 300,000 (the same as Beaufort, the smallest BLHC System studied).

If only one minute of physician time per examination were saved by utilizing two examination rooms per doctor (for example the physician need not wait for one patient to dress following an examination before seeing the next patient with two examination rooms) the net present value savings over 25 years would be $235,536. A four-minute savings would save $1,317,144 over the same period. This savings can be realized without decreasing the quality of health care.

Alternative 5. Outpatient Surgery

Outpatient Surgery (Surgicenter) is designed for patients needing minor surgery. These are patients who could arrive in the morning, have their operation performed under the required anesthesia, recover in the recovery room, and be returned home accompanied by a responsible adult before the end of the day.

The concept is applicable to surgical procedures which do not require extensive pre- or post-operative care -- approximately 20 percent of all surgical procedures now done in the hospital (primarily for military dependents).

The following represents the estimated economic impact of ambulatory surgery in Military Base Level Health Care System.

In the primary BLHC Systems studied by Westinghouse, the number of surgical procedures ranged from approximately 1000 per year to 3600 per year. If we assume that 20 percent of these procedures can be accomplished on an ambulatory basis and that two and one-half of the normal three days of post operative can produce a savings of 500 beds days in the smaller system and 1800 in larger systems. This savings is primarily in light care.

The Westinghouse functional costs show a direct savings in labor from wards, dietary and laundry of $12.50 per light care day and in supplies of $2.50 per light care day. The first year savings for the smaller system would then be $7,500 and in the larger system $27,000 over a 25 year life cycle.

BLHC System surgical costs can be significantly reduced as shown in Table 3.3-23.

TABLE 3.3-23

POTENTIAL SAVINGS UTILIZING TWO EXAMINATION ROOMS PER PHYSICIAN

(300,000 OPD Visits Per Year, 75,000 Visits Affected).

Saved Time in Minutes/Exam	Savings per Year	Gross 25 yr.* Present Value Operating Cost Savings	Additional Rooms Required	Cost of Additional Rooms	Net Savings
1	$25,000	$352,536	39	$117,000	$235,536
4	$102,000	$1,410,000	31	$93,000	$1,317,000

*Based on 4% Labor Inflation and 10% Discounted Cost of Money

SURGICENTER COST SAVINGS

No. Beds	Total Surgical Procedures	Out-Patient Procedures	Savings In Bed Days	First Year Savings	Life-cycle Savings
250	1,000	200	500	$ 7,500	$122,000
750	3,600	720	1,800	27,000	441,000

WARD MANAGEMENT

Ward Management - the application of nursing and administrative services to individual wards -- is presently the largest single personnel cost in the BLHC System. Because of rapidly increasing costs and general unavailability of nursing personnel, ward management urgently needs an in-depth study of present and alternative staffing and organizational procedures.

At present, the total nursing and ward support staff required is generally determined by relating nurses to the nominal number of patients for which the facility is designed. This staffing need is usually calculated as hours per day of nursing time needed for the "average" patient in each specialty and/or ward. This procedure is satisfactory only if patient dependent mix remains constant, not only in the total system but on a ward by ward basis. One of the prime objectives of any staffing or organizational structure should be one that is flexible enough to recognize and adapt quickly to changes in the number and mix of patients, and to workload and performance variations. This would give more efficient staffing and organizational procedures with a probable improvement of quality of care.

Sound personnel policies will supply a working climate which is conducive to nursing excellence and achievement, while increasing job satisfaction and decreasing job tensions and turnover.

TECHNICAL APPROACH

The Westinghouse data gathering and analysis activities enabled the Study Team to compile a detailed set of data concerning the present methods of ward management at the BLHC Systems. Using the data gained in the State-of-the-Art Survey and work performed by consortium team members, the implications of alternatives were calculated and compared against the present system.

PRESENT STAFFING METHOD

The following operational and staffing data is the result of work sampling studies at Beaufort, Malcolm Grow, and Walson military hospitals. For verification of the data, these results were compared with previous Westinghouse studies of civilian hospitals. A work sampling study of 25 nursing activities revealed that the following eight work categories comprise the major portion of ward management activities:

1. Patient Care -- direct patient contact (administering medication, giving backrubs, changing sheets), or services performed at a distance from the patient but which directly affect his well-being (preparing medication at the Nursing Station, preparing bandages, or preparing an IV bottle).
2. Administrative Clerical -- Supervision: writing office reports, daily census slips and weekly time sheets, and giving or receiving instructions; Communications: recording information (charting nurses' notes, making out the diet list, transcribing orders, and checking inventory).
3. Housekeeping.
4. Instructional -- primarily on-the-job training of corpsmen and continuing education of nursing staff personnel.
5. Outside Unit, Ward Related -- escorting a patient or running errands off the unit.
6. Travel time -- time spent in the unit moving between rooms and work area, and delivering supplies.
7. Unrelated activities -- personal and idle time (including lunch and coffee break), and being off the unit for reasons unrelated to ward activities.
8. Unobserved activities -- person could not be found or was off the unit for an unknown reason.

The results of the work sampling studies are presented in the Data Inventory volume. A summary of the results is shown in Table 3.3-24 which expresses nursing time devoted to each activity as a percentage of the total time on the job.

The Westinghouse study attempted to generate an overall statement of general characteristics for the present system; however, the sample is quite limited (three primary study hospitals) and some additional comments and qualifications are listed below.

1. Time devoted to patient care at Walson appears to be significantly higher than at Beaufort and Malcolm Grow. Walson also shows a higher percentage of time devoted to patient care on the second shift than on the first, while Beaufort shows decreased percentages. (Malcolm Grow was not studied in-depth on the second shift.)
2. Nurses at Walson spend a lesser percentage of their time on administrative and clerical tasks than do nurses at the other two BLHC Systems. This difference cannot be explained as a result of lower staffing on second shift because Beaufort also had lower staffing on second shift.
3. Walson devotes considerable time to instruction, probably because of its emphasis on on-the-job training programs.
4. Housekeeping time is lowest at Walson because this service is contracted to an outside agency.
5. Errand and escort time shows a wide variation between the three BLHC Systems.
6. Idle and personal time shows little variation between hospitals and would appear to be independent of service and scale.
7. Unobserved activities are significantly higher at Walson.
8. Table 3.3-24 shows the average time for all shifts devoted to a work classification; however, variations between shifts were observed. For example, patient care consumes 34.9 percent of total time

TABLE 3.3-24

WARD MANAGEMENT WORK SAMPLING*

Hospital	Andrews		Beaufort		Walson		Total	
Sample Size	817		617		1223		2657	
General Activity Grouping	Actual %	Precision Interval ± %	Actual %	Precision Interval ± %	Actual %	Precision Interval ± %	Actual %	Precision Interval ± %
Patient Care	30.7	2.8	29.7	3.5	42.1	2.8	35.7	2.0
Administrative & Clerical	24.5	3.0	24.9	3.3	19.2	2.3	22.1	1.7
Instructional	0	-	0.9	.7	4.8	1.2	2.2	.7
Housekeeping	3.7	1.4	3.0	1.3	1.6	.7	2.6	.6
Outside Unit (Ward Related)	1.1	.7	10.1	2.2	6.2	1.3	5.5	1.0
Travel Time	14.2	2.5	[illegible]	2.1	1.8	.7	6.8	1.0
Unrelated Activities	24.1	3.0	23.2	3.2	19.7	2.4	21.9	1.6
Unobserved Activities	1.7	1.0	1.1	.9	5.2	1.2	3.2	.7

*All calculations based on standard 95% confidence level.

on the first shift, 42.3 percent on the second. Actual man hours devoted to patient care decrease on the second and third shifts because total staffing is reduced. Administrative and clerical duties consume 22.7 percent of available time on the first shift and 17.8 percent on the second. Almost all housekeeping and instruction is done on the first shift. Escorting and business off the ward increases greatly on the second shift. Idle, personal, and lunch time is fairly constant for all shifts.

9. Variations in workload emphasis during shifts were also observed. Patient care is highest early in the morning and steadily declines as the day progresses. Administrative and clerical work at Walson and Dix peaks at 1600 to 1700 hours, then falls off rapidly; Beaufort peaks at 0900 - 1000 hours. Peaks are also noticeable for travel, idle, personal, and housekeeping time.

As indicated above, the Study Team compared these data obtained from observations in general, medical, surgical, orthopedic and pediatric wards with data obtained from prior civilian hospital studies to determine whether there were major differences in the utilization of ward management personnel that would immediately indicate areas for improvement.

Civilian ward management personnel devote a higher percentage of their time to patient care and administrative duties than those in the BLHC Systems studied. This may be expalined by a difference in patient dependency, that is, civilian patient mix is generally more acute. It may also be due in part to the observed tendency of military patients to assist each other and to assume a significant percentage of the ward management functions. Apart from these minor variations, there were no apparent major differences.

Staffing analysis of sixteen military hospital units, utilizing the University of Michigan study methodology (Appendix 3.3-2) indicates a range of staff requirements per occupied patient bed of from two to sixteen nursing staff hours.

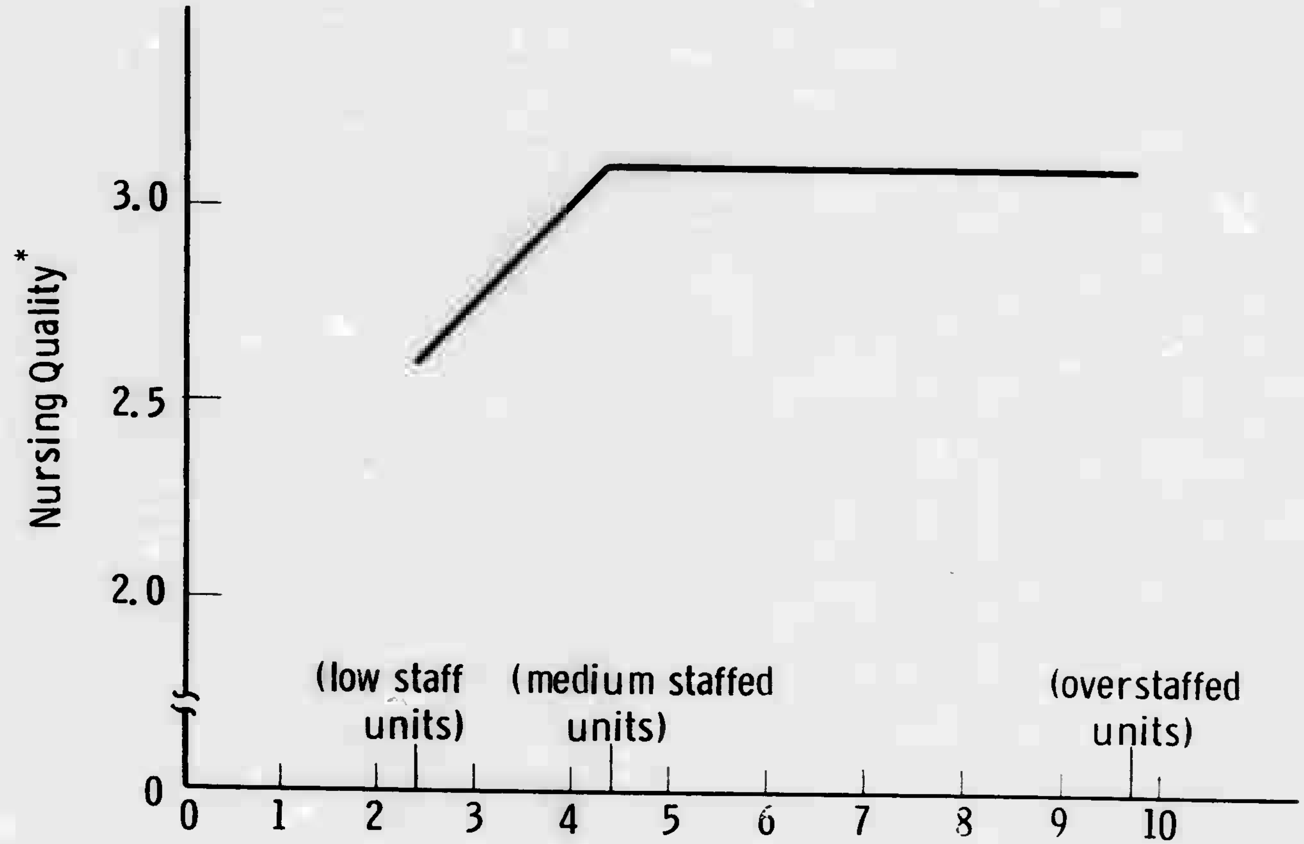
A review of the nursing units from which these data were obtained indicates that differences in patient dependency levels could not adequately account for such a wide range of total nursing time per occupied bed (refer to Figure 3.3-43).

The data were re-examined to compare levels of staffing and types of staffing mix to quality of care (as defined in Appendix 3.3-2). "Low" staffing was defined as 1.9 - 4.1 nursing hours per occupied bed day; "medium" staffing as 4.2 - 6.1; and "high" staffing as 6.2 - 16.0. From this analysis the Study Team concluded that:

1. Average quality of care (as measured by the University of Michigan methodology) observed in medium- and high-staffed units is approximately equal, but significantly higher than that of low-staffed units. (See Figure 3.3-38).
2. Staff hours per bed on wards where the present bed occupancy rate is lowest.
3. High-staffed units employ 50 percent RN's; medium-staffed, 45 percent; and low-staffed, 40 percent, indicating that relatively expensive personnel are being under-utilized in high-staffed units.
4. Understaffing decreases costs but also tends to effect an observable lowering of the quality of patient care as defined by this technique.
5. Overstaffing is expensive and inefficient and does not improve the quality index significantly.

PRESENT ORGANIZATION PROCEDURES

Ward management organizations in the three primary BLHC Systems were similar with one exception: as hospitals become larger, administrative and clerical personnel increasingly relieve the nurse of non-patient care duties. For example, Figure 3.3-39 shows the organization at Beaufort,

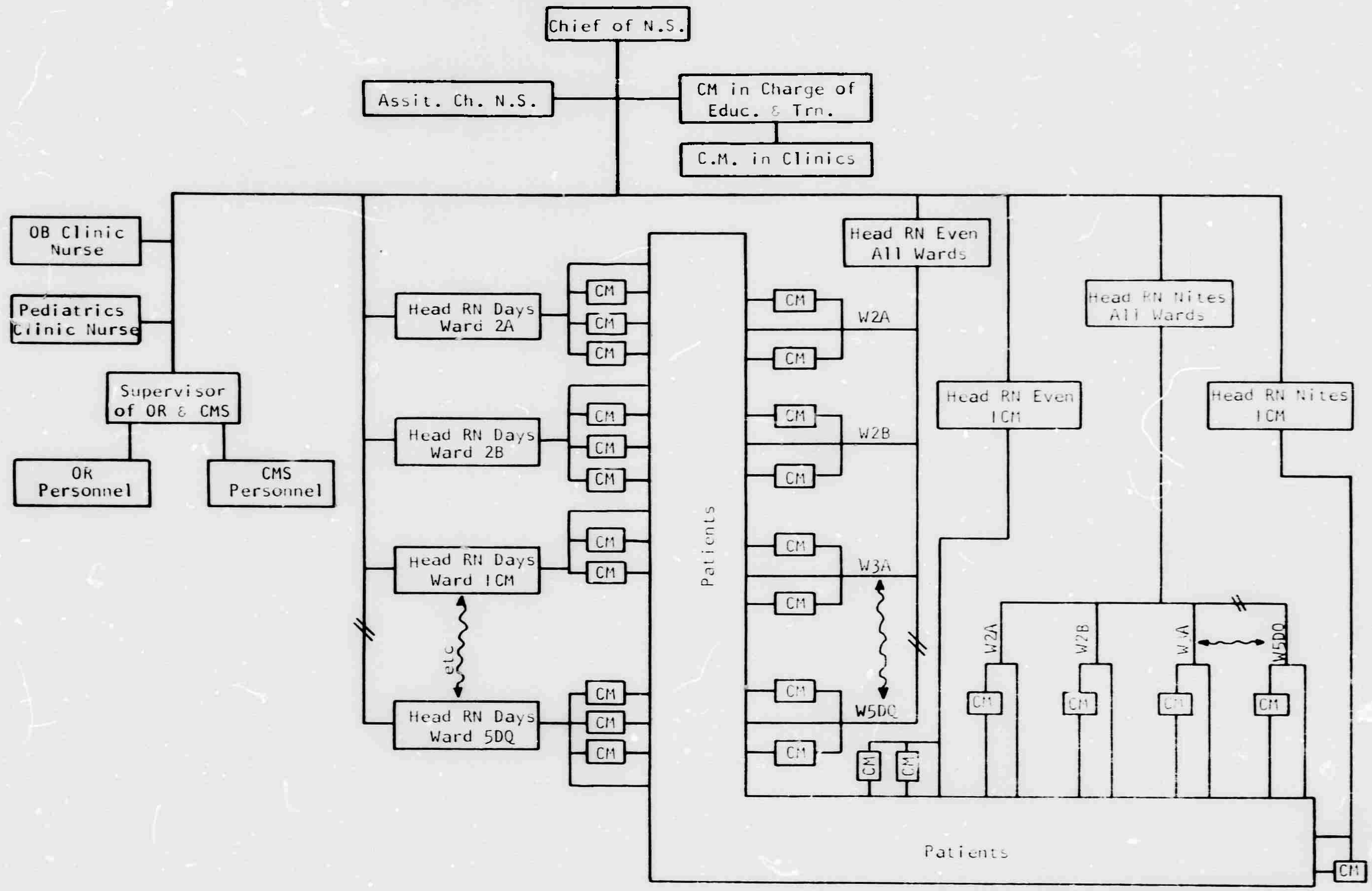


TOTAL STAFF (NURSE AND CORPSMAN) HOURS PER PATIENT DAY

FIGURE 3.3-38 - NURSING QUALITY-STAFF HOURS RELATIONSHIP

*Based on University of Michigan Methodology - Appendix 3.3-2, page A42

Fig. 3.3-39 Existing Nursing Organization Beaufort Naval Hospital



the smallest hospital studied, and Figure 3.3-40, the organization at Walson, the largest hospital studied.

The University of Michigan approach was used to obtain an understanding of ward management in terms of how the various organizational factors may influence performance (Fig. 3.3-41). This study concluded that the cost-quality relationships are observable and can be qualified (refer to Table 3.3-25). General conclusions are:

(1) The smaller the turnover in the staff, the higher the performance (it should be noted that military turnover can be partly controlled, for example, length of tours of duty).

(2) Formal reporting structure has a strong effect on performance. There are many elements to this conclusion, however; performance improves greatly when the professional nursing staff (RN and LPN) reduce their responsibility for non-professional activities (clerical, housekeeping, dietary, supplies, etc.)

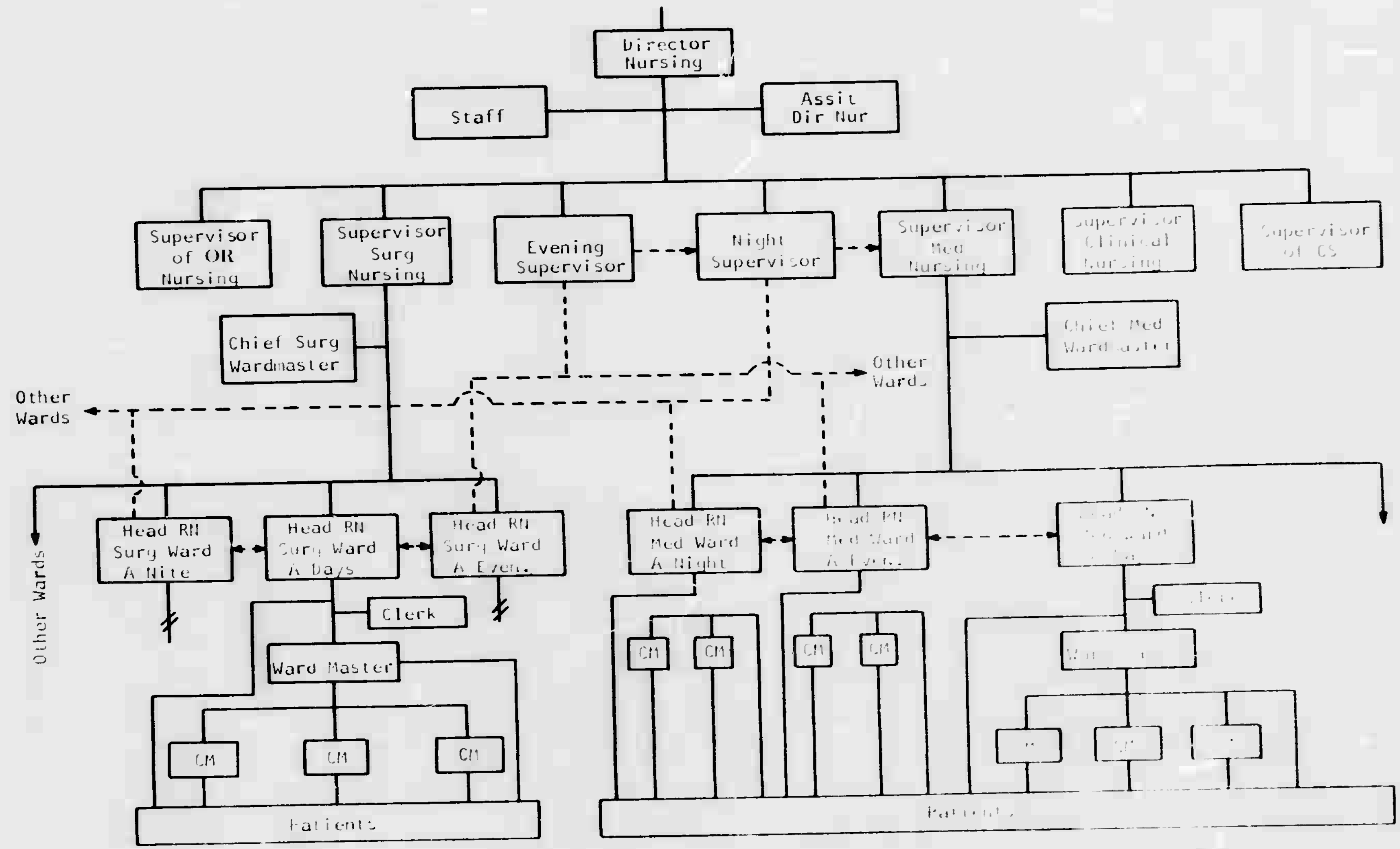
(3) Information organization affects performance primarily in two areas:

- A more participative style of management at the patient unit level leads to higher performance.
- A clearer understanding of an individual's responsibilities within the organization leads to higher performance.

(4) Personnel satisfaction is affected by organizational characteristics and, furthermore, personnel satisfaction has a positive effect on performance and reduces turnover.

(5) Workload, based on patient volume and type, education, and research programs in the hospital are important considerations in establishing cost. They represent a significant portion of personnel activities.

Fig. 3.3-40 Existing Nursing Organization W. A. H. - Dix



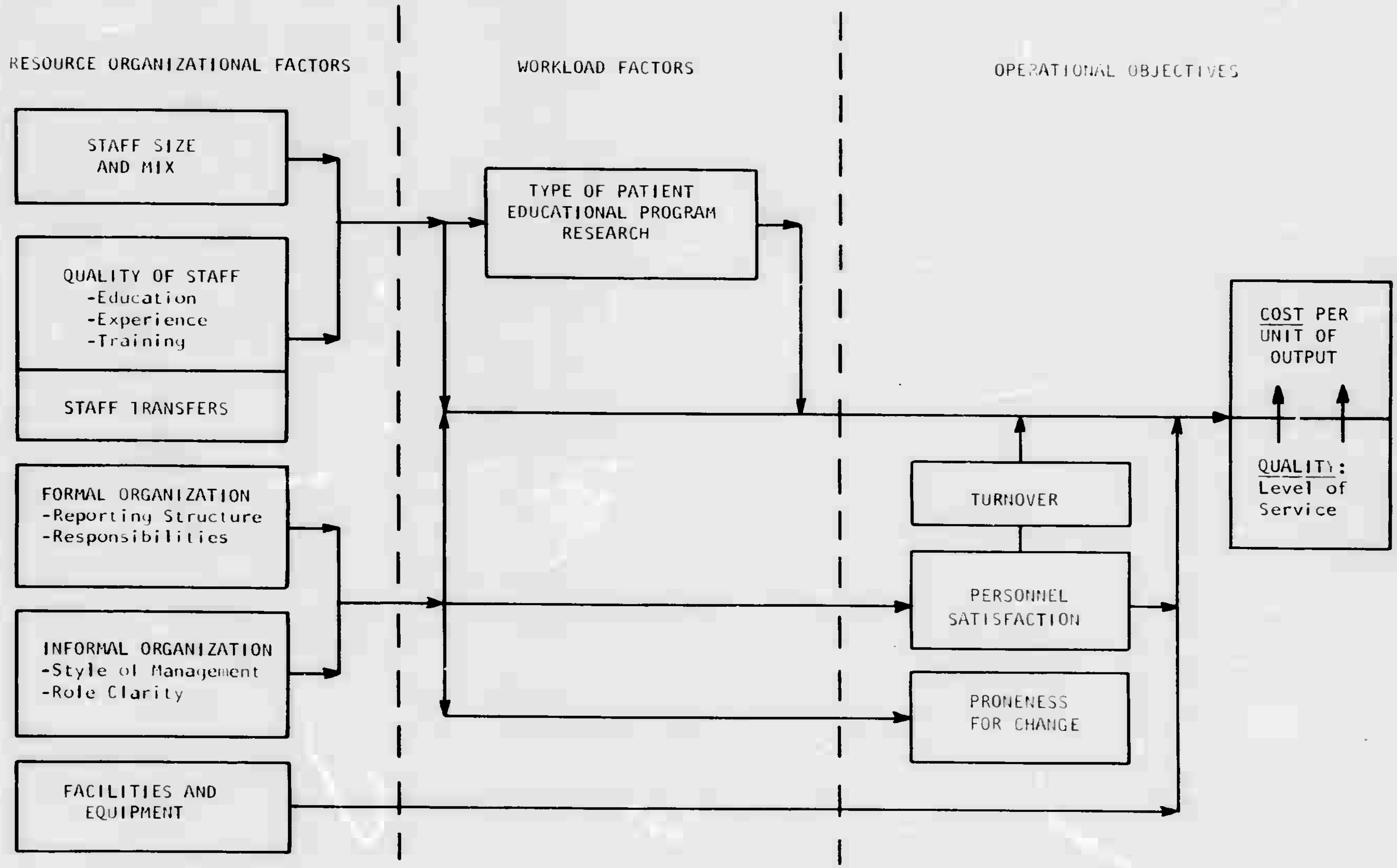


FIG. 3.3-41 - CONCEPTUAL MODEL OF THE PATIENT CARE OPERATION

[illegible]		[illegible] $ *	[illegible] **				Bed	[illegible]	[illegible] ***			[illegible]
			RN	LPN	Corp	Other			1	2	3	
Andrews	(Wards)											
	1E	99.673	6	-	6	-	9	6	0	[illegible]	1	[illegible]
	2A	174.228	12	2	6	1	40	38	0	1[illegible]	24	[illegible]
	2B	123.353	7	-	9	1	28	27	4	[illegible]	1	[illegible]
	2H	116.030	8	4	5	-	54	30	6	1[illegible]	10	Female [illegible]
	3A	167.241	7	7	6	1	32	23	2	21	0	Ped[illegible]
	3B	135.860	11	6	1	1	74	30	2	19	[illegible]	OB-[illegible]
	3D	126.852	11	3	1	-	43	18	2	16	0	Labor [illegible]
	4B (4A)	124.602	10	1	27	1	68	26	3	11	1[illegible]	[illegible] ward
	5B	124.913	8	1	7	1	68	68	30	10	28	Orthoped
	5A (5B)	167.618	9		12	2	68	40	1[illegible]	10	16	Medical ward
Beaufort Naval Hospital	(Wards)							not available				
	3B	56.739	1.6	-	4	-						[illegible]
	2A	73.954	1.7	-	6	-						Internal Med
	2B	62.376	2.2	-	4	-						[illegible] surgery
	4S (SOO)	93.575	4.1	-	9	-						SOQ
	5S (SDQ)	83.666	4.9	-	3	6						SOQ
	3A	43.561	1.6	-	5	-						Orthopedics
Walson Army Hospital (Dix)	(Wards)											
	2A	99.783	5	-	6	-	45	30		9	21	Male Surgical
	3A	122.806	6	3	12	2	34	12			7	Pediatric [illegible] Air Evac)
	4A	70.320	2		7	3	6[illegible]	3			3	24-Hr [illegible] Transient Pats
	5A	73.106	3.5	-	7	-	73	28		13	15	Surgical
	6A	105.126	4.5	-	9	-	53	39		12	2	Orthoped
	7A	94.183	5.5	-	9	-	73	47			[illegible]	[illegible]
	8A	83.427	4.5	-	8	-	[illegible]	49			49	[illegible]
	9A	117.653	6	-	11	-	[illegible]	42		16	2[illegible]	Medical
	2B	120.645	6	2	9	3	42	22		12	10	Female Medical-Surgical
	3B	142.099	8	1	9	1	32	13		13	[illegible]	Obstetric
	4B	165.372	7	-	15	2	54	20			12	[illegible]
	5B	70.964	3.5	-	6	-	[illegible]	[illegible]		1	22	Medical
	6B	93.786	4.5	-	6.5	-	[illegible]	34		1[illegible]	0	[illegible]
	8B	76.891	4.5	-	8	-	[illegible]	32		11	[illegible]	[illegible]
	9B	204.096	10	-	18	3	[illegible]	26	.	1	[illegible]	[illegible]
	2C	166.366	8	3	12	-	1[illegible]					
	3C											
	SC											
	PC											
	ER											
	NS											
	NN											
	SS											
	37											
	GB											
	7B											

TABLE 3.3-25. QUALITY AND COST RELATIONSHIPS OBSERVED IN THE THREE PRIMARY BLHCS

* Includes fringe benefits.
** Count includes all three shifts. LPN's are civilian personnel.
*** 1=Complete Dependency; 2=Normal Dependency; and 3=Light Dependency.

Hospital Function/		Clinical Quality Index 6	Task Quality Index 7	Overall Quality Index 8	SATISFACTION/ Mean/No Work Related Index 1	External Index 2	Interpersonal Index 3	Residual Index 4	Overall Index 5
		Mean/No.	Mean/No	Mean/No.					
Andrews	(Wards)								
	1E	3.0/4	3.2/3	3.1/4	23.9	1.5/9	.9/9	1.8/9	2.1/9
	2A	2.9/4	2.2/4	2.8/4	2.4/10	2.5/10	1.6/10	2.3/10	3.1/10
	2B	3.4/1	3.0/1	3.3/1	1.2/6	1.3/6	.4/6	1.5/6	1.7/6
	2H	3.4/2	3.7/2	3.2/2	3.1/6	2.0/6	1.0/6	1.8/6	2.5/6
	3A	0.0/0	0.0/0	0.0/0	2.6/4	2.9/4	2.4/1	2.9/4	2.7/4
	3B	3.7/1	3.5/1	3.7/1	2.0/2	2.0/2	.5/2	1.3/2	1.5/2
	3D	3.0/4	3.0/4	3.0/4	1.3/6	1.7/6	1.5/6	1.2/6	1.8/6
	4B (4A)	0.0/0	0.0/0	0.0/0	.5/1	1.2/1	1.0/1	1.8/1	2.0/1
	5B	2.6/3	2.5/3	2.6/3	2.3/8	2.2/8	.8/8	2.0/8	2.7/8
	5A (5B)	3.1/1	3.0/1	3.1/1	2.0/6	1.5/6	.7/6	1.7/6	1.3/6
		Total 3.0/20	Total 2.9/19	Total 3.0/20	Total 2.1/58	Total 1.9/58	Total 1.1/58	Total 1.9/58	Total 2.3/58
Beaufort Naval Hospital	(Wards)								
	3B	3.9/3	4.4/4	3.9/4	1.7/13	1.7/13	.6/13	1.1/13	2.2/13
	2A	3.6/1	3.0/1	3.4/1	1.7/5	1.1/5	1.1/5	1.4/5	1.8/5
	2B	2.9/2	3.5/2	3.0/2	1.7/3	.3/3	1.7/3	1.8/3	4.0/3
	4S (SOQ)	4.4/1	3.0/1	4.1/1	2.2/3	1.2/3	.9/3	1.4/3	1.0/3
	5S (SDQ)	4.7/1	4.5/1	4.7/1	2.2/2	2.2/2	.8/2	1.5/2	2.0/2
	3A	3.3/2	3.5/2	3.3/2	2.4/5	1.2/5	.5/5	1.1/5	1.8/5
		Total 3.7/10	Total 3.8/11	Total 3.7/11	Total 1.9/31	Total 1.4/31	Total .8/31	Total 1.3/31	Total 2.1/31
Walson Army Hospital (Dix)	(Wards)								
	2A	2.9/4	2.3/3	2.8/4	1.9/6	1.0/6	.6/6	1.2/6	2.0/6
	3A	3.2/6	3.7/6	3.3/6	1.2/8	1.1/8	.7/8	.9/8	1.5/8
	4A	0.0/0	0.0/0	0.0/0	.9/2	.8/2	1.0/2	.6/2	.5/2
	5A	3.9/1	4.0/1	3.9/1	0.0/1	0.0/1	0.0/1	0.0/1	0.0/1
	6A	2.5/5	3.0/5	2.6/5	2.4/9	1.2/9	1.1/9	1.5/9	2.1/9
	7A	2.0/7	2.6/7	2.2/7	2.6/13	1.2/13	1.4/13	2.1/13	2.3/13
	8A	2.2/3	2.8/3	2.4/3	1.5/3	.4/3	.8/3	1.0/3	1.0/3
	9A	3.1/5	2.4/4	3.0/5	1.8/10	1.4/10	1.0/10	1.1/10	1.8/10
	2B	3.1/4	2.7/4	3.0/4	2.1/3	1.3/4	.7/4	1.2/4	1.5/4
	3B	3.4/4	3.2/4	3.3/4	2.4/4	1.2/4	.9/4	1.0/4	1.5/4
	4B	2.7/6	3.1/6	2.9/6	1.5/7	.9/7	.8/7	1.2/7	1.0/7
	5B	4.2/2	3.7/2	4.1/2	2.2/3	.7/3	.8/3	1.9/3	2.7/3
	6B	2.4/1	3.0/1	2.6/1	2.2/4	1.8/4	1.7/4	2.2/4	1.5/4
	8B	3.6/1	4.0/1	3.7/1	2.1/2	.9/2	.2/2	1.8/2	3.0/2
	9B	3.3/10	3.1/10	3.3/10	1.1/16	1.6/16	1.1/16	1.1/15	1.5/15
	2C	3.9/7	3.9/7	3.9/7	1.7/12	1.3/12	.8/12	1.3/12	1.1/12
	3C	2.1/2	3.5/2	2.5/2	2.0/2	.8/2	1.8/2	1.4/2	2.0/2
	SC	0.0/0	0.0/0	0.0/0	1.2/1	.8/1	.7/1	1.2/1	1.0/1
	PC	3.3/1	4.0/1	3.4/1	2.0/1	.4/1	1.3/1	1.4/1	3.0/1
	ER	2.1/2	2.0/2	2.1/2	2.0/6	.9/6	.8/6	1.5/6	1.7/6
	NS	2.9/1	2.5/1	2.8/1	3.5/2	2.1/2	1.8/2	2.9/2	1.5/2
	NN	3.4/1	3.0/1	3.3/1	1.0/1	.2/1	1.3/1	.6/1	0.0/1
	SS	3.7/1	3.0/1	3.6/1	2.2/1	1.4/1	1.0/1	2.4/1	3.0/1
	32	2.5/5	2.5/5	2.5/5	2.0/5	.6/5	.6/5	1.4/5	2.0/5
	GB	0.0/0		0.0/0	.5/1	1.2/1	0.0/1	-.4/1	1.0/1
	7B	2.6/1		2.9/1	2.2/1	1.2/1	.3/1	1.8/1	2.0/1
		Total 13.0/60		Total 13.0/80	Total 1.8/124	Total 1.2/125	Total 1.0/125	Total 1.4/124	

TABLE 3.3-25 - CONTINUED

Hospital Function/		TENSION, Mean/No Nursing Index 15	Corpman Index 16	External Index 17	Total Index 18	Decision Making Index 19	[illegible] Mean/No [illegible] Index 20	[illegible] Index 21	P. L. Index 22
Andrews	(Wards)								
	1E	3.6/8	3.9/9	3.9/8	3.7/9	8.1/8	12.1/8	13.2/5	11.6/8
	2A	3.5/8	3.6/9	3.9/8	3.7/8	8.4/10	11.3/10	12.[illegible]/10	11.[illegible]/10
	2B	4.1/6	4.4/6	3.7/6	4.0/6	13.1/5	14.7/5	1[illegible].0/[illegible]	13.[illegible]
	2H	3.0/6	3.1/5	3.2/6	3.1/6	6.5/6	12.2/6	13.0/6	9.0/[illegible]
	3A	3.0/4	3.5/4	3.1/3	3.2/4	7.9/4	10.7/4	10.9/4	[illegible]
	3B	3.7/2	4.6/2	4.0/2	4.0/2	9.2/2	10.5/2	13.2/2	11.[illegible]/2
	30	3.4/6	4.6/6	3.8/6	3.8/6	8.7/4	13.4/4	13.2/4	[illegible]/4
	4B (4A)	3.0/1	4.0/1	4.4/1	3.8/1	16.0/1	13.0/1	1[illegible].5/1	1[illegible]/1
	5B	3.1/8	3.4/8	2.6/8	3.0/8	9.7/7	12.6/7	11.2	[illegible]
	5A (5B)	4.3/6	4.5/6	3.6/6	4.0/6	12.7/6	13.2/6	16.7/6	[illegible]/6
		Total 3.5/55	Total 3.9/56	Total 3.5/54	Total 3.6/56	Total 9.4/53	Total 12.3/53	Total 13.[illegible]	Total 11.[illegible]/52
Beaufort Naval Hospital	(Wards)								
	3B	3.7/11	3.6/13	3.7/11	3.7/12	10.7/12	11.9/12	14.1/2	10.3/11
	2A	3.9/4	3.6/5	3.5/5	3.7/5	7.1/5	9.8/5	11.2/5	3.[illegible]/5
	2B	4.6/3	3.6/3	4.4/3	4.3/3	9.8/3	13.0/3	1[illegible]	11.[illegible]/3
	4S (SOQ)	3.7/3	3.5/3	4.3/2	3.8/3	8.3/2	13.0/2	14.1/2	9.[illegible]/2
	5S (SDQ)	3.8/2	3.8/2	4.6/1	4.2/2	11.0/1	12.0/1	8.[illegible]/1	13.0/1
	3A	3.7/3	3.6/5	4.0/4	3.9/4	11.5/5	12.8/5	14.4/5	12.[illegible]/5
		Total 3.8/26	Total 3.6/31	Total 3.9/26	Total 3.9/29	Total 9.9/28	Total 11.9/28	Total 13.5/28	Total 10.8/2[illegible]
Walson Army Hospital (Dix)	(Wards)								
	2A	3.9/5	4.2/5	3.9/5	3.9/5	9.1/6	13.1/6	14.2/6	10.1/6
	3A	4.1/8	4.5/8	4.3/6	4.4/6	10.0/7	12.9/7	14.8/[illegible]	12.9/7
	4A	3.2/2	3.4/2	3.9/2	3.6/2	7.8/2	15.3/2	14.4/2	14.7/2
	5A	3.7/1	4.0/1	4.0/1	3.9/1	11.7/1	15.3/1	16.0/1	13.0/1
	6A	3.4/9	3.5/8	3.7/6	3.6/7	8.4/9	12.6/9	13.1/9	9.9/9
	7A	3.7/12	3.8/12	4.3/12	3.9/13	10.0/13	12.7/13	14.2/13	11.9/13
	8A	4.5/3	4.2/3	4.5/3	4.5/3	11.0/3	16.0/3	15.[illegible]/3	9.7/3
	9A	3.4/9	3.5/10	3.3/10	3.3/10	9.7/9	12.4/9	13.4/9	8.1/9
	2B	3.2/4	3.0/4	[illegible].0/4	3.1/4	6.9/3	[illegible].2/3	10.0/3	9.0/3
	3B	3.8/4	3.9/4	3.9/4	3.8/4	11.3/3	14.3/3	15.2/3	12.0/3
	4B	4.2/5	3.9/5	4.2/4	4.1/5	14.8/6	15.4/6	13.5/6	13.6/6
	5B	4.1/3	4.1/3	4.0/3	4.0/3	12.6/3	14.1/3	14.1/3	10.[illegible]/3
	6B	2.7/4	3.0/4	3.3/3	3.0/4	9.7/4	14.4/4	13.2/4	10.7/4
	8B	4.2/2	4.2/2	4.3/2	4.3/2	7.3/1	13.0/1	14.7/1	13.5/1
	9B	4.0/14	4.2/15	4.4/14	4.2/15	10.5/15	12.8/15	14.3/15	12.0/15
	2C	3.7/9	4.1/11	4.0/9	4.0/10	10.2/11	11.5/11	13.[illegible]/11	12.[illegible]/11
	3C	3.8/2	3.3/2	4.5/2	4.0/2	5.7/2	13.2/2	12.5/2	8.[illegible]/2
	SC	0.0/0	3.6/1	4.0/1	3.9/1	7.7/1	14.7/1	18.5/1	17.5/1
	PC	3.2/1	3.2/1	4.0/1	3.6/1	11.0/1	14.7/1	13.0/1	11.0/1
	ER	3.8/4	4.0/6	3.5/6	3.7/6	12.8/6	13.7/6	13.[illegible]	13.2/6
	NS	3.7/2	4.0/2	3.3/2	3.6/2	8.7/2	11.2/2	12.1/[illegible]	11.[illegible]/2
	NN	4.0/1	3.2/1	4.8/1	4.2/1	13.3/1	16.0/1	12.2/1	15.0/1
	SS	3.0/1	3.0/1	2.7/1	2.9/1	[illegible].3/1	13.[illegible]/1	[illegible]/1	8.5/1
	32	4.3/5	4.2/5	4.4/5	4.3/5	8.1/4	14.1/4	11.[illegible]	8.[illegible]
	GB	0.0/0	5.0/1	0.0/0	0.0/0	13.3/1	16.0/1	1[illegible]/1	[illegible].0/1
	7B	0.0/0	0.0/0	0.0/0	0.0/0	10.0/1	13.0/1	1[illegible]/1	9.[illegible]/1
		Total 3.8/100	Total 3.9/117	Total 4.0/10[illegible]	Total [illegible].9/11[illegible]	Total 10.1/11[illegible]	Total 13.1/11[illegible]	Total 13.[illegible]	Total 11.3/11[illegible]

TABLE 3.3-25 - CONTINUED

Hospital Function/		TEAM COOPERATION/Mean/No. Index 9	Index 10	Index 11	Index 12	Index 13	Index 14
Andrews	(Wards)						
	1E	3.9/9	3.2/9	3.8/9	3.1/9	3.6/8	4.0/9
	2A	3.4/9	2.8/9	2.7/9	3.6/9	3.4/9	3.6/9
	2B	4.2/6	3.3/6	4.0/6	4.0/6	3.8/6	3.7/6
	2H	3.2/5	2.7/4	2.7/4	1.7/4	3.2/4	3.5/4
	3A	3.5/2	3.0/2	3.5/2	3.5/2	4.5/2	4.5/2
	3B	3.5/2	3.5/2	3.0/2	3.5/2	3.5/2	3.5/2
	3D	4.2/5	4.2/5	3.4/5	4.4/5	4.4/5	4.4/5
	4B (4A)	5.0/1	5.0/1	4.0/1	5.0/1	4.0/1	5.0/1
	5B	3.4/8	3.1/8	2.7/8	3.7/8	3.5/8	4.2/8
	5A (5B)	4.2/6	3.7/6	4.0/6	4.2/6	4.2/6	4.3/6
		Total 3.8/53	Total 3.3/52	Total 3.3/52	Total 3.6/52	Total 3.7/51	Total 4.0/52
Beaufort Naval Hospital	(Wards)						
	3B	3.4/12	2.7/13	3.3/12	3.3/3	3.6/13	4.0/13
	2A	3.8/5	3.8/5	3.6/5	4.0/5	4.2/5	4.0/5
	2B	3.3/3	2.7/3	3.7/3	4.0/3	3.7/3	3.3/3
	4S (SOQ)	4.0/3	3.3/3	3.3/3	3.0/3	4.3/3	4.0/3
	5S (SDQ)	4.0/2	3.5/2	4.0/2	4.5/2	3.5/2	5.0/2
	3A	3.6/5	4.0/5	3.4/5	2.8/5	3.8/5	2.6/5
		Total 3.6/30	Total 3.2/31	Total 3.5/30	Total 3.5/31	Total 3.8/31	Total 3.7/31
Walson Army Hospital (Dix)	(Wards)						
	2A	3.7/6	3.3/6	2.8/6	3.7/6	3.5/6	3.8/6
	3A	4.2/8	3.6/8	4.0/8	3.5/8	4.1/8	4.0/8
	4A	4.0/2	4.5/2	4.0/2	3.0/2	4.0/2	3.5/2
	5A	4.0/1	4.0/1	4.0/1	3.0/1	4.0/1	5.0/1
	6A	3.1/9	2.7/8	2.6/9	2.8/9	2.9/9	3.3/9
	7A	3.5/13	3.2/13	3.5/13	2.8/13	3.6/13	3.5/13
	8A	3.7/3	3.7/3	3.7/3	1.7/3	3.7/3	3.3/3
	9A	3.2/10	2.7/10	3.2/10	2.7/10	3.0/10	2.9/10
	2B	3.5/4	3.0/4	3.3/4	3.0/4	3.2/4	3.5/4
	3B	4.5/4	3.2/4	3.7/4	3.7/4	4.5/4	3.2/4
	4B	3.9/7	3.6/7	3.7/7	3.1/7	3.9/7	3.7/7
	5B	3.7/3	3.0/3	3.3/3	3.3/3	3.7/3	4.0/3
	6B	3.7/4	3.2/4	3.2/4	3.2/4	3.5/4	3.2/4
	8B	4.5/2	3.5/2	3.5/2	1.5/2	3.0/2	4.0/2
	9B	3.7/16	3.2/16	3.6/16	4.1/16	4.0/16	4.1/16
	2C	3.8/12	3.7/12	3.6/12	4.0/12	4.0/12	3.6/12
	3C	3.5/2	3.0/2	2.5/2	2.0/2	3.5/2	3.0/2
	SC	4.0/1	4.0/1	5.0/1	5.0/1	5.0/1	4.0/1
	PC	2.0/1	2.0/1	2.0/1	3.0/1	3.0/1	3.0/1
	ER	4.2/6	3.8/6	3.5/6	3.7/6	4.0/6	3.8/6
	NS	3.0/2	2.5/2	3.0/2	1.5/2	3.5/2	2.5/2
	NN	4.0/1	4.0/1	3.0/1	3.0/1	4.0/1	3.0/1
	SS	4.0/1	2.0/1	3.0/1	2.0/1	4.0/1	4.0/1
	32	3.6/5	3.2/5	3.0/5	2.4/5	3.6/5	3.4/5
	GB	3.0/1	5.0/1	4.0/1	5.0/1	5.0/1	5.0/1
	7B	4.0/1	3.0/1	4.0/1	0.0/0	3.0/1	3.0/1
		Total 3.7/125	Total 3.3/124	Total 3.4/125	Total 3.2/124	Total 3.7/125	Total 3.6/125

TABLE 3.3-25 - CONTINUED

Improvement Alternatives

Improvement alternatives were grouped into two categories:

(a) Those relating to the estimate of the gross numbers and type of staff to be authorized and assigned to the BLHCS's ward management function.

(b) Those relating to the organization and application of these staff to the ward management functions.

The staffing alternatives were selected to represent the full range of staffing methodology while the organizational alternatives were selected from the state of the art.

Staff Estimating Alternatives

Alternative #1. Present Method. This was typified by the Work Center Manning Standards used by the Air Force. This method is based on the use of work sampling studies in existing facilities, extending for a 15-day period to ensure that a full array of work patterns are observed and recorded. Figures 3.3-42 and 43, developed from these studies, are used to relate total estimated required staffing man hours for a given level of "average patients" in several broad nursing categories. Staff is authorized for a BLHC System on this basis. (Actual staffing patterns at the primary study hospitals are approximately 90 percent of authorized staffing.)

Alternative #2. The Johns Hopkins Method. This method is based on assigning staff by patient dependency level assuming that each level of dependency requires its own discrete level of staffing. The expected average daily patient load must be defined in terms of three patient dependency levels as developed by R. J. Connor, Johns Hopkins University - self care; intermediate care; and intensive care. Staffing requirements for each level have been calculated from previous studies

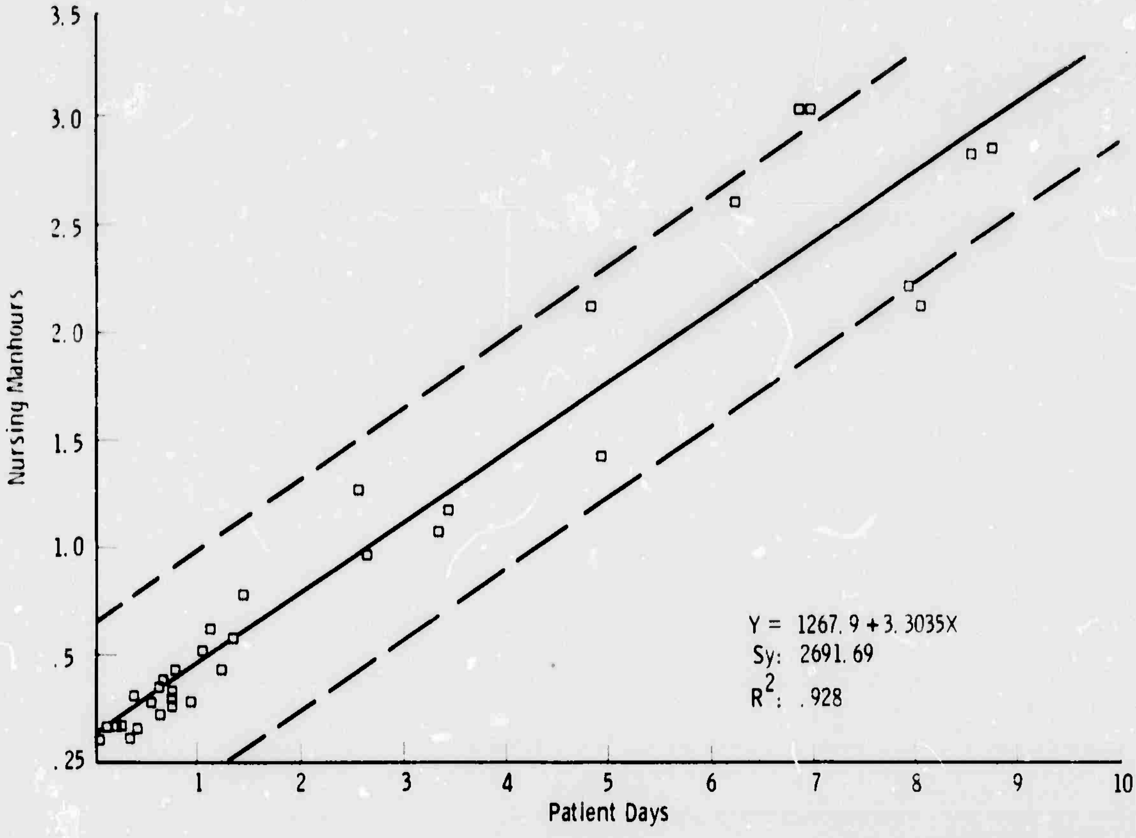


FIG. 3.3-42 - MEDICAL SURGICAL NURSING UNITS RESOURCE ALLOCATION

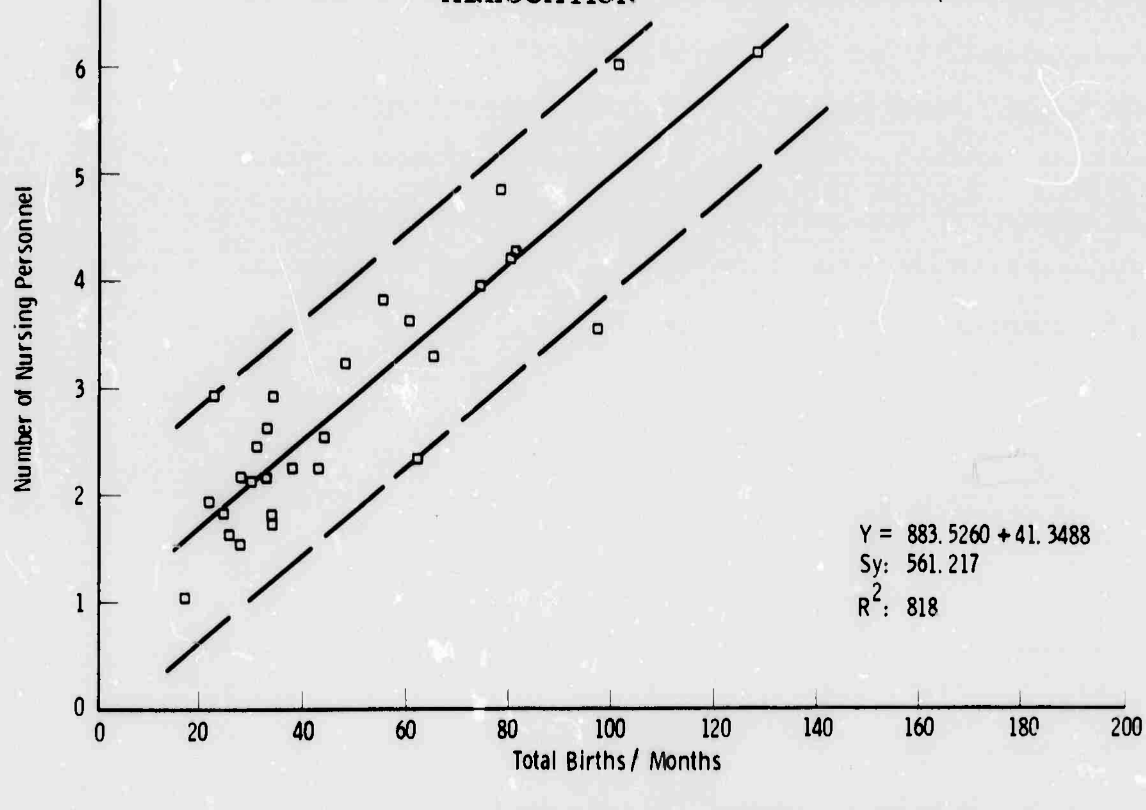


FIG. 3.3-43 - OBSTETRICAL NURSING UNIT RESOURCE ALLOCATION

and these requirements are assigned to the patient mix. Total man hours are converted into staff and a total authorization required for patient care. To this is added a constant of 20 man hours per day per 30-bed ward to compensate for duties which must be performed independently of the number and type of patients. The total nurse staffing is then calculated as follows:

$$PA = 20 + .5N_1 + 1.0N_2 + 2.5N_3$$

where: PA = total productive hours of staffing time required

N_1, N_2, N_3 = the number of patients in dependency categories 1, 2, and 3 respectively.

Alternative #3. Massachusetts Hospital Group NSMC. This method classifies patients into minimal, intermediate and complete care, comparable to The Johns Hopkins categories. Time demands for each patient level per "normal and complete" patient days were established, based on data obtained from nineteen hospitals. In addition, adjustments are made for admission and discharge days, for example an intermediate dependency patient would require 2.53 hours of care on the day of admission rather than 3.27 hours on subsequent days. Time values are:

Dependency	Percent of Patient Days	Required Hours of Care per Day
Minimal	13	2.79
Intermediate	31	3.27
Complete	40	4.47
Admission Day	8	2.53
Discharge Day	8	1.58
Average Patient	100	3.46

<u>Alternative #4. The University of Michigan Method.</u> This method is based on using a ratio of staff hours to patient occupied bed days that is compared with a measure of quality. Cost, expressed in staff hours per patient day, can be adjusted for varying patient dependencies (need for nursing personnel time) to form a Standard Need Index. Cost (personnel hours) and quality are then related and plotted, as shown for the three BLHC hospital standards on Figure 3.3-44. This shows that while a definite relationship between cost and quality exists, there is a point on the curve where spending additional money for personnel offers sharply diminishing increases in quality.

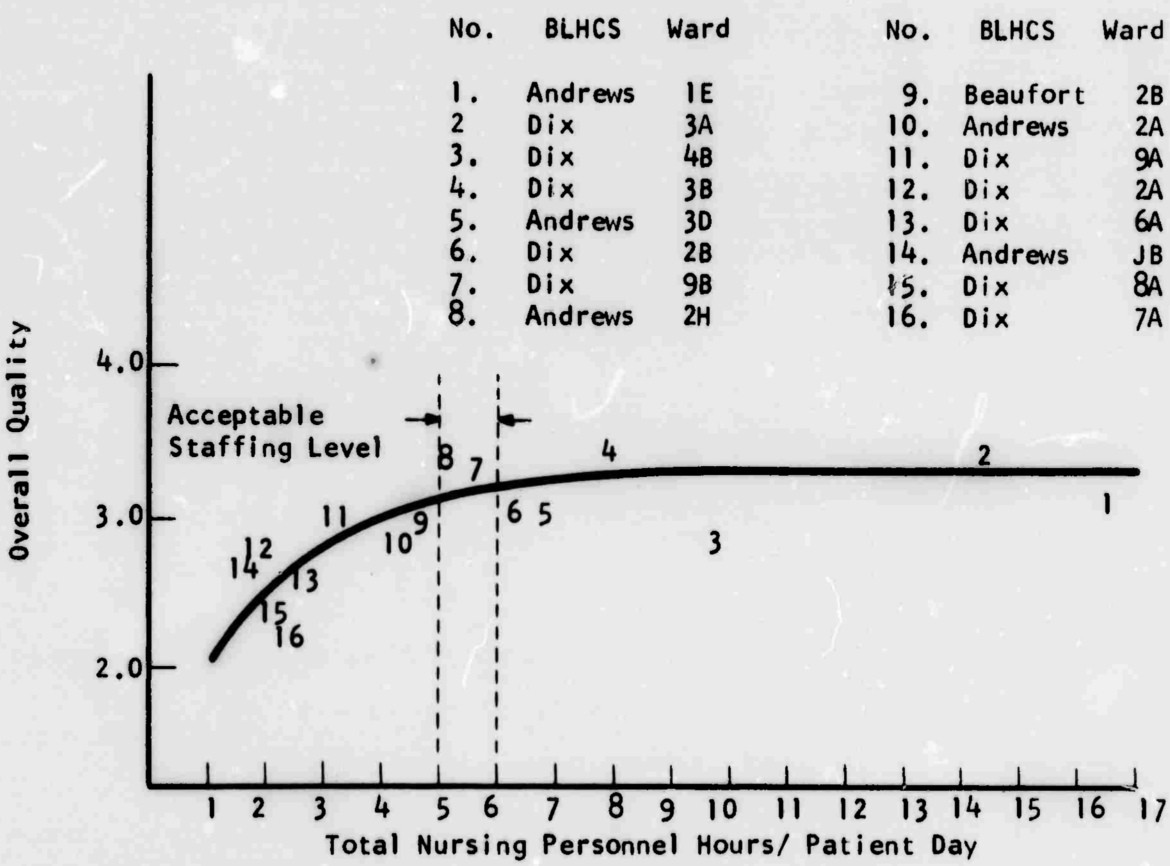


FIG. 3.3-44 - PERSONNEL HOURS PER PATIENT DAY VS. OVERALL QUALITY (See Appendix 3.3-2)

Alternative #5. The Westinghouse "Graduate" Staffing Method. This method draws heavily on Veterans Administration Nursing Activity Time Standards, and is the most comprehensive staffing alternative. It is the only alternative which considers the four major factors influencing nursing workloads: quality of care, type of patient, degree of patient dependency, and type of nursing skill required.

Workload is established from four data inputs:

- Time standards for patient-related activities, developed specifically for an individual hospital, or modified from existing lists.
- Time standards for activities which are not patient-related, such as administrative and clerical work, developed the same way as the patient-related standards.
- Adjustments to the two time standards for all defined activities by nursing skill level to determine what type of nursing staff skill should perform each activity and which could perform each activity. For a given activity, the following could occur:

	Nursing Personnel Who:	
Class of Patient Care	Should Perform	Could Perform
I	RN	LPN
II	LPN	-
III	LPN	Aide

- Two additional factors are then applied to the time standards:
  1. A Work Distribution Factor (WDF), derived from the total workload per patient day, is applied to the activity level expected on each shift.

2. A performance factor, evaluating such items as fatigue, personal time, degree of workload leveling, and interferences between activities and personnel.

From these four inputs, a series of lists detailing (1) time per activity by class of patient care and (2) tasks unrelated to patient care are prepared and correlated with work distribution and performance factors. Table 3.3-26 illustrates how total time needed per day by each class of nurse is computed. Table 3.3-27 illustrates how work distribution and performance factors are applied to establish total staffing needs.

TABLE 3.3-26

TOTAL WORKLOAD CALCULATION

Nursing Personnel Class: LPN-Aide

Activities	Class of Patient Care I	II	III
Activity A	0 min.	10 min.	4 min.
Activity B	18 "	12 "	6 "
Activity C	0 "	0 "	7 "
Activity D	15 "	8 "	22 "
Activity E	8 "	8 "	8 "
Total Time/day/patient	41 min.	38 min.	47 min.

Patient Class	No. Patients	Time/Patient (min.)	Total (min.)	Total Staff*
I	5	41	205	.4270
II	15	38	570	1.1875
III	10	47	470	.9791
Totals	30		1245	2.5937

$$\text{*Total Staff} = \frac{\text{Total Minutes}}{60 \times 8}$$

TABLE 3.3-27

WORK DISTRIBUTION AND PERFORMANCE FACTORS FOR STAFFING NEEDS

Personnel Categories: Should do Task	Could do Task	Notation for Fig. 3.3-45	Col. #4 Total Amount of Time Required Per Day Converted Into Man Days	Col. #5 WFD	Col. #6 $1-PF_s$	Col. #7 No. Persons Required Day Shift $\frac{\text{Col. \#4} \times \text{Col. \#5}}{\text{Col. \#6}}$
RN	RN	$N_{1,1}$	2.40	.55	.80	1.65
RN	LPN	$N_{1,2}$	2.47	.55	.80	1.70
LPN	LPN	$N_{2,2}$	4.07	.55	.80	2.80
LPN	Aide	$N_{2,3}$	3.64	.55	.80	2.50
Aide	Aide	$N_{3,3}$	3.20	.55	.80	2.20
		TOTAL	15.78			10.85

The procedure for determining final staff mix is shown in Figure 3.3-45. The various nursing categories are placed in a "graduate" according to professional skills required; workload which can be done by RN's only is put in first; by LPN's, second; and by aides, last. After the nurses, activities are plotted. The number of nurses needed is determined by going up the "graduate" to the next whole number. LPN and aide needs are determined in a similar manner. In Figure 3.3-45 staffing needs are two RN's, 5 LPN's, and 4 aides.

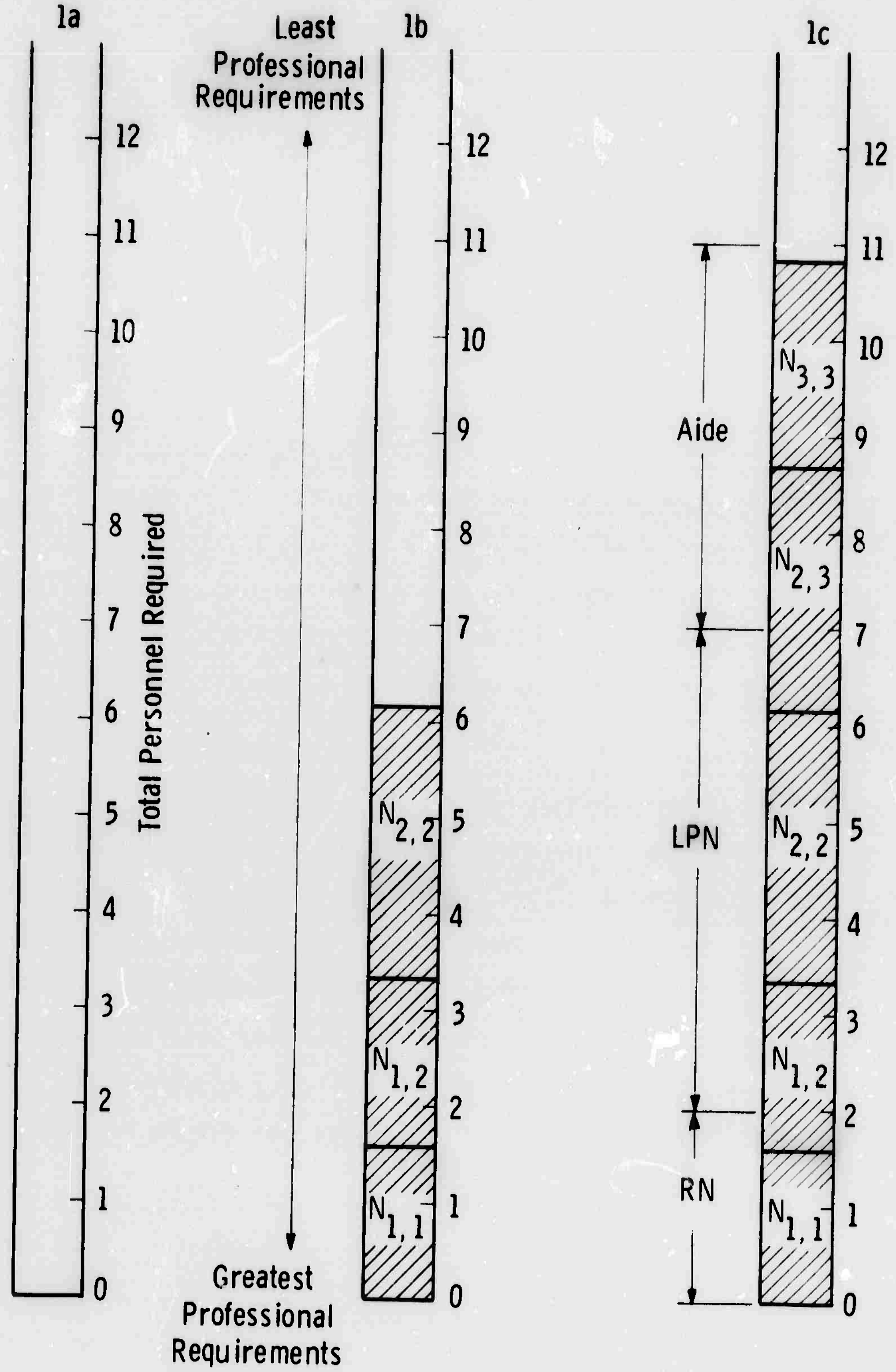


FIG. 3.3-45 - STAFF DETERMINATION PROCEDURE

IMPROVEMENT ALTERNATIVES

Organization

Organization structure was studied by expanding three organizational concepts to five improvement alternatives. The three general concepts are: present military, unit manager, and nursing specialist. The five improvement alternatives considered are:

Alternative #1. The present military organization structure (Figures 3.3-39 & 40). The head nurse is responsible for health care and ward administration which too often results in poor performance of both duties. Its advantages, however, include: single-person responsibility and control within each ward, and operational flexibility to practice team or functional nursing.

Alternative #2. Conventional Unit Manager (Figure 3.3-46). With clerks and a unit manager on each floor, a transfer of administrative and clerical responsibilities to a unit manager, frees the nurse for patient care duties. This alternative is also operationally flexible enough to enable team or functional nursing. Disadvantages include strict requirements for job descriptions to eliminate any misunderstandings of duties and the possibility of having two "bosses", and its general limitation to the day shift. Unit managers should be either a lieutenant, a warrant officer, or high-ranking enlisted man.

Alternative #3. The Area Unit Manager Organization (Figure 3.3-47) This is a variation of the conventional unit manager approach with the same general advantages and disadvantages. Because the area unit manager has broader duties than the ward unit manager, he should probably be an officer.

FIG. 3.3-46 - CONVENTIONAL UNIT MANAGER VARIATION #1

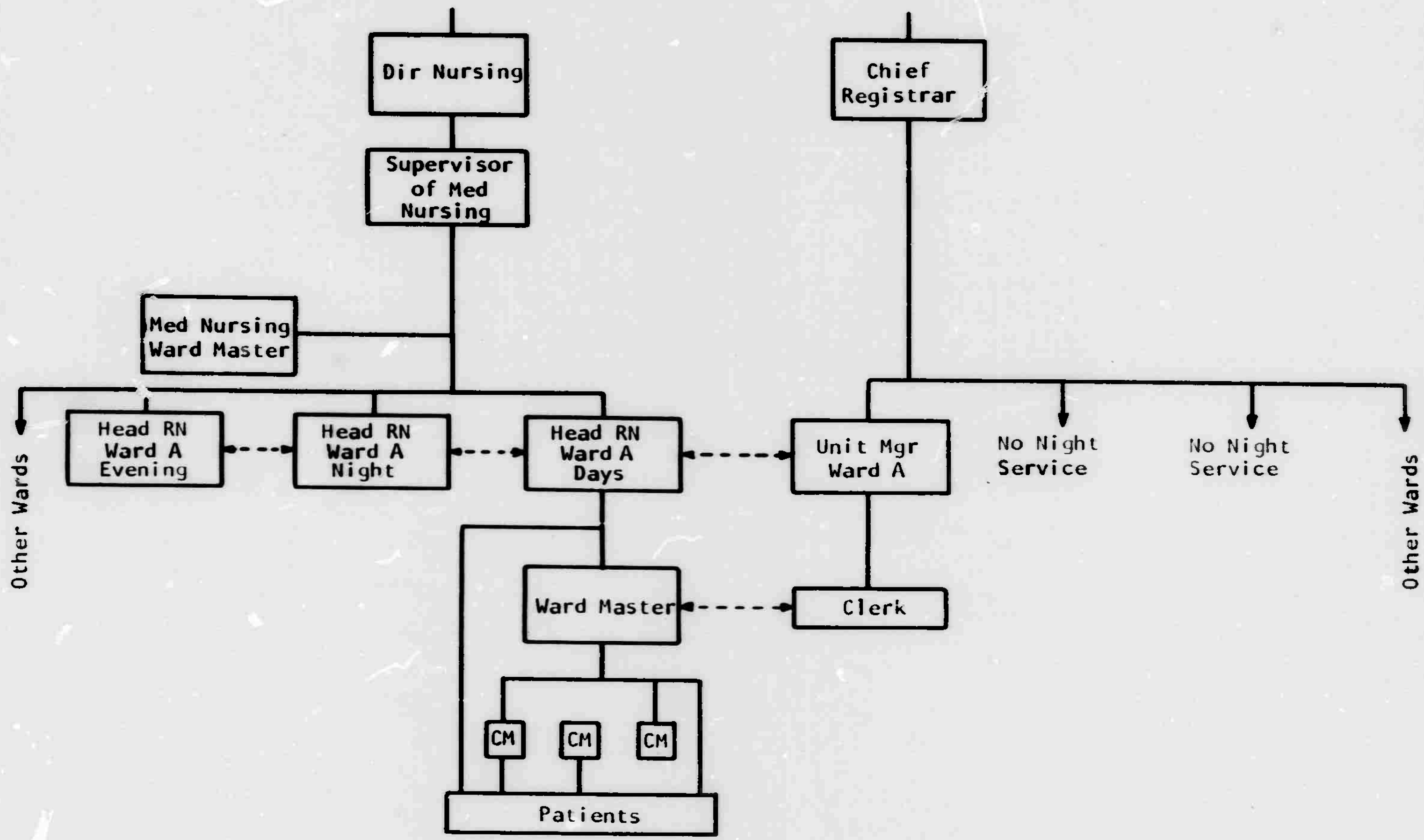
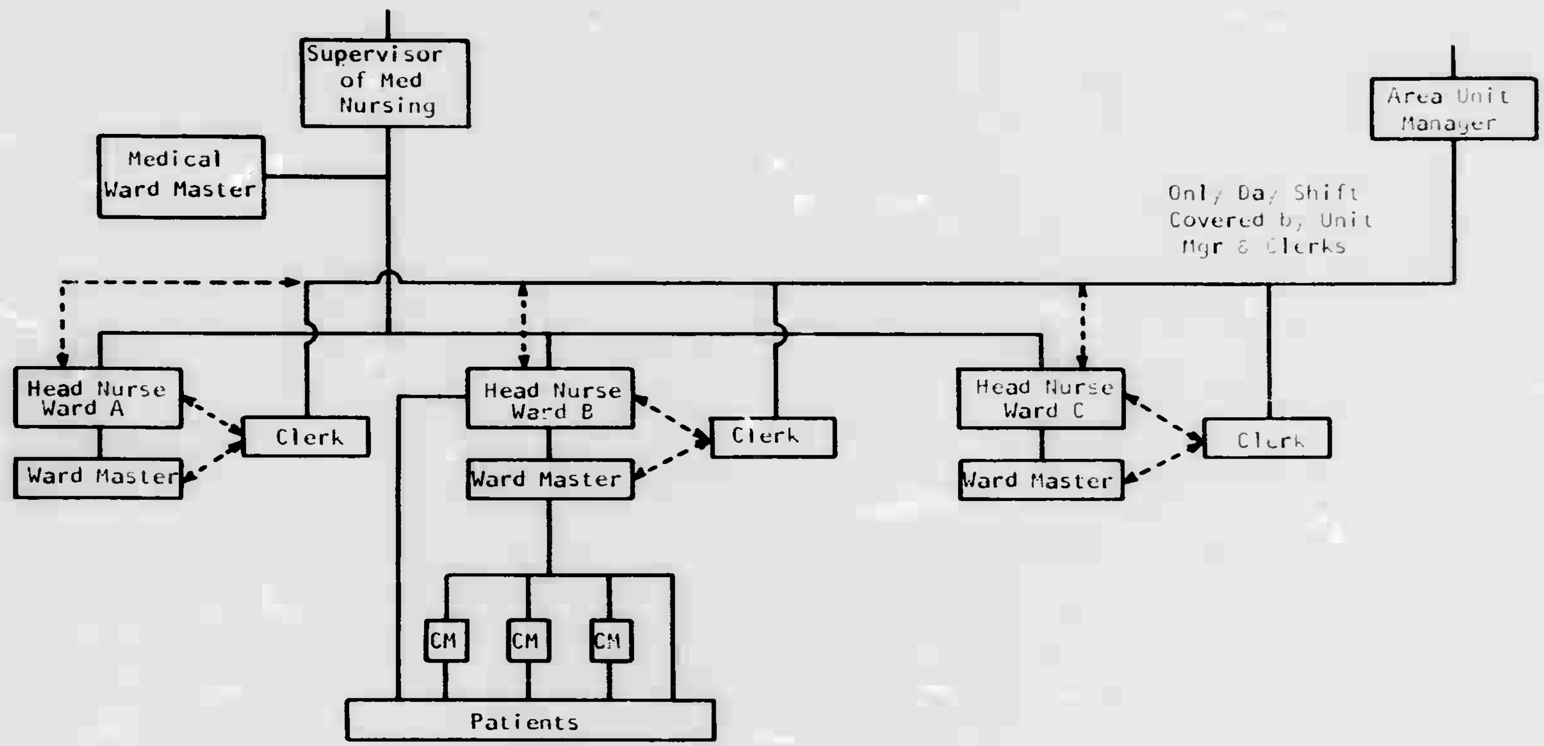


FIG. 3.3-47 - CONVENTIONAL UNIT MANAGER - VARIATION #2



Alternative #4. Nursing Specialist, Added to the Area Unit Manager Organization, (Figure 3.3-48). This Alternative eliminates the head nurse on each unit. Each unit is managed by a wardmaster who reports to a nursing specialist. The nursing specialist supervises all health care activities through the wardmaster, but can also administer health care to specific patients as required. Nursing specialists are most often used in a staff consulting capacity.

In view of the hostility and resistance demonstrated by head nurses and supervisors to this concept wherever it has been installed, the concept being considered has been altered to place the nursing specialist in a line position in place of the head nurse. Another problem with the nursing specialist alternative is the general lack of qualified personnel able to assume the specialist's duties.

Alternative #5. The Modified Nursing Specialist, Unit Manager Organization (Figure 3.3-49.) This alternative places the unit manager in a role where he reports to the head nurse who, in turn, reports to a nursing specialist. Clerical and administrative functions are assumed by the unit manager on all shifts; friction between the unit manager and nursing care coordinator is eliminated; the nursing care coordinator reports to a nursing specialist, who, in addition to being responsible for the quality of care administered in all of her units, can also be in direct charge of the nursing care for specific patients. The administrative and clerical duties formerly performed by the nursing supervisor are now performed by the wardmaster. Fewer nursing specialists are needed in this alternative than in the conventional nursing specialist alternative. Definite job descriptions are required.

FIG. 3.3-48 - VARIATION OF NURSING SPECIALIST - UNIT MANAGER CONCEPT

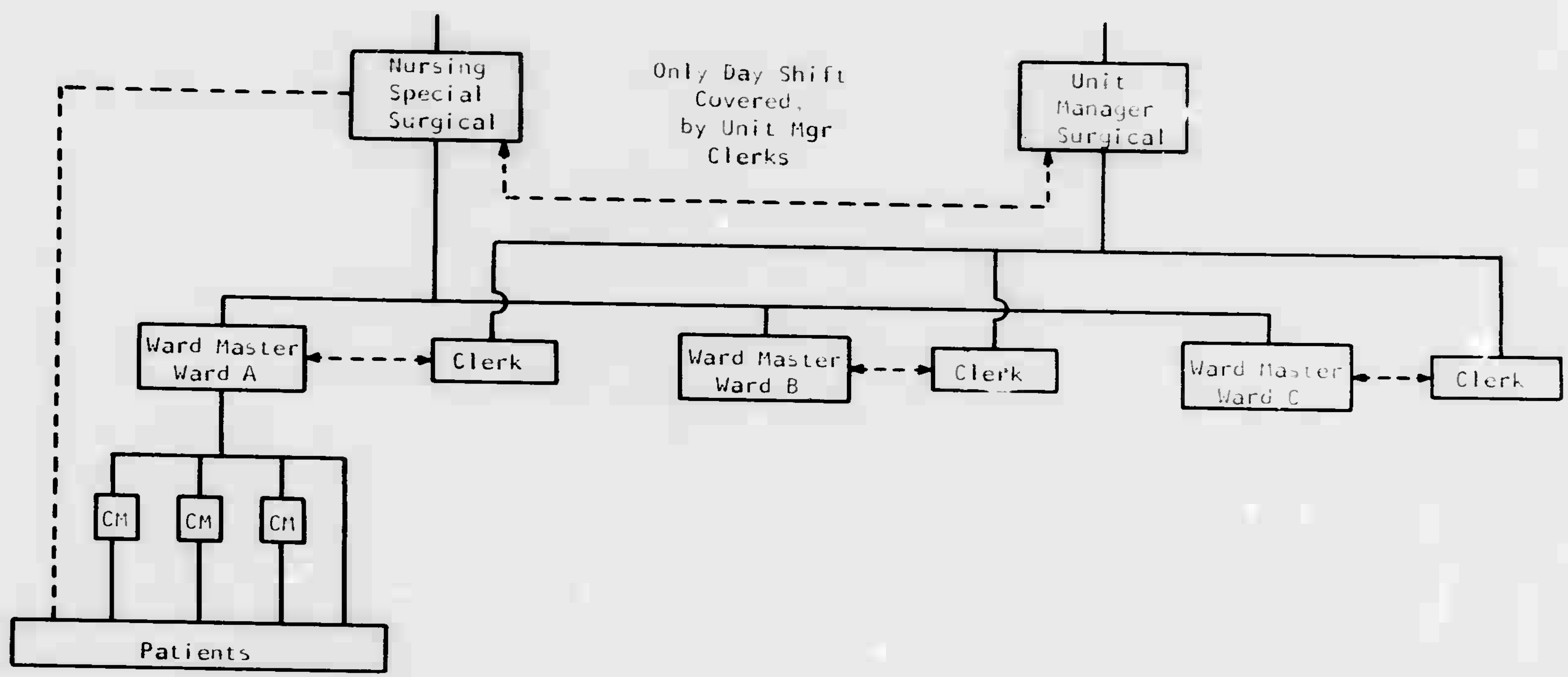
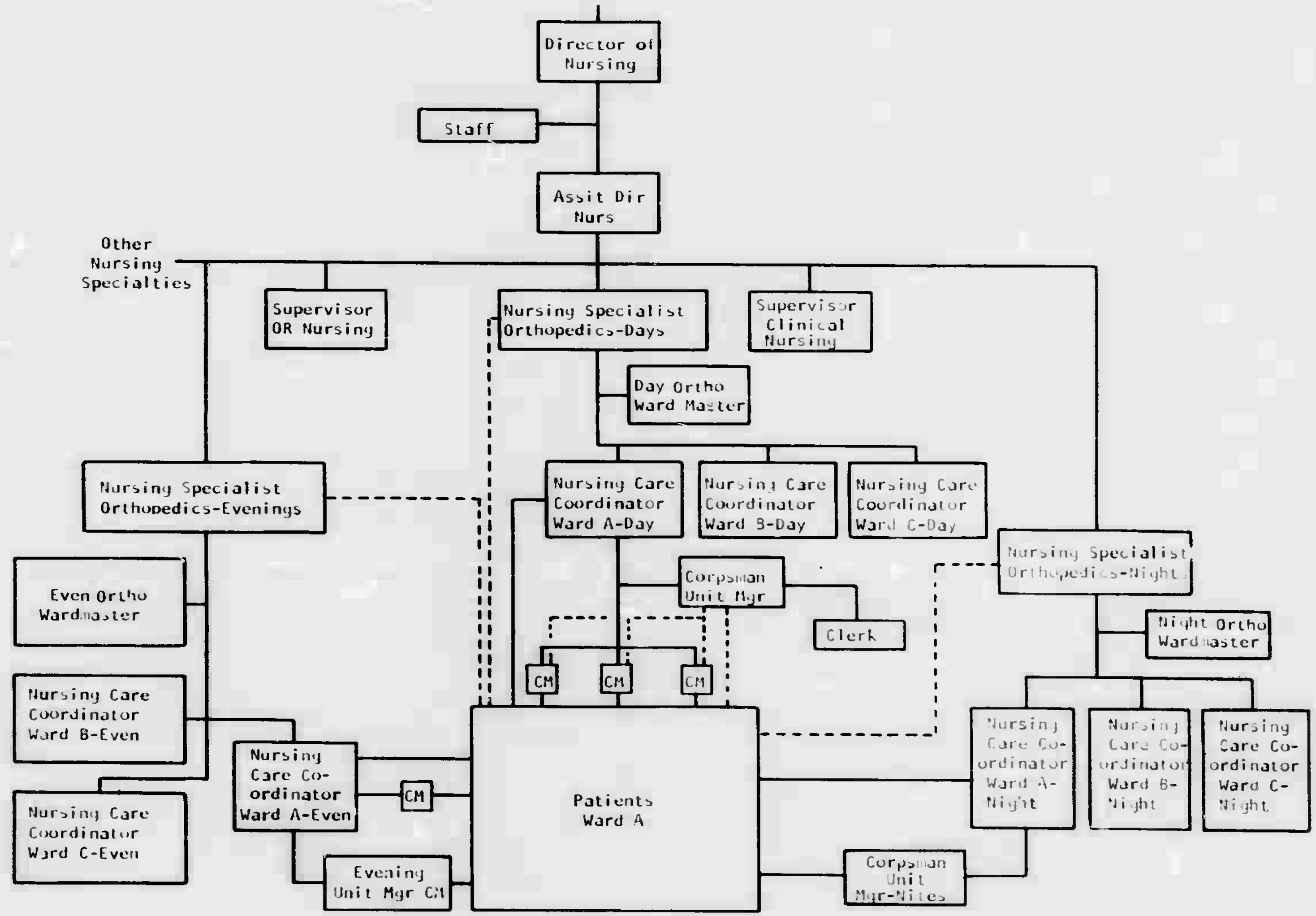


Fig. 3.3-48—Modified nursing specialist, unit manager organization



ANALYSIS OF ALTERNATIVES

Staffing

Each staffing estimating method (Alternatives #1 through #5) was applied to a hypothetical, 500-bed hospital with a patient mix representative of the BLHC System as a whole. The staff requirements, in terms of gross numbers and types of personnel, were determined and tabulated in Table 3.3-28. Authorized military staffing was reduced by 10% to reflect actual conditions.

The wide variations in total staffing between the five alternatives leads to the conclusion that the comparability and reliability of all results must be questioned especially when comparing the military to the civilian hospital method of delivering patient care. Many activities, such as meal and mail distribution, making beds, assisting patients to move about, which are done by nursing personnel in civilian hospitals are done by ambulatory patients in the military hospitals.

Table 3.3-28 also presents the evaluation of staff mix for each alternative. Although the Westinghouse "Graduate" Staffing method shows twenty-nine fewer total people than the present military method, total personnel costs are about $217,000 per year higher. It is possible, however, that emphasis was placed on performing activities by personnel with higher skills than was necessary. Also the time value used by the V.A. is probably be completely applicable to DoD.

In addition to these quantitative data, a further set of qualitative evaluations were necessary to determine whether the alternative was based on a method which could be readily adapted to the military system. These evaluations, displayed in Table 3.3-29, include:

- Procedures: Takes into account patient level of dependency, medical type of patient, nursing skill required, some measure of quality and admission/discharge workload.

TABLE 3.3-28 - COST EVALUATION OF STAFFING ALTERNATIVES

Personnel* Category	Functional Cost Pay/ Category	Act. Military Staff No.	Dollars	Work Sampling Act. No.	Dollars	U. of Mich. 6.0 hrs. No.	Dollars	U. of Mich. 5.5 hrs. No.	Dollars	U. of Mich. 5.0 hrs. No.	Dollars	Mass. Hosp. NSMC No.	Dollars	Johns Hopkins No.	Dollars	"Graduate" No.	Dollars
General Nursing	$14,400	103	1,483,200	95	1,368,000	113	1,627,200	102	1,468,800	94	1,353,600	87	1,252,800	82	1,180,800	113	1,627,200
Medical Services Supt.	12,128	2	24,256	2	24,256	2	24,256	2	24,256	2	24,256	2	24,256	2	24,256	2	24,256
Medical Services Tech.	9,113	20	182,260	19	173,147	23	209,599	21	191,373	19	173,147	17	451,921	16	145,808	81	738,153
Medical Services Spec.	5,516	99	546,084	92	507,472	108	595,728	98	540,568	90	496,440	83	457,828	81	446,796	55	303,380
Apr. Medical Services Spec.	4,289	102	437,478	93	398,877	110	471,790	100	428,900	96	411,744	86	368,854	82	351,698	46	197,294
TOTAL		326	2,673,278	301	2,471,752	356	2,928,573	323	2,653,897	301	2,459,187	275	2,258,659	263	2,149,358	297	2,890,283

*Air Force Work Center Manning Standards - Medical Functions FCS100-5422

TABLE 3.3-29 - WARD STAFFING CRITERIA EVALUATION[1]

Staffing Criteria	Takes into Account: Level of Depend.	Takes into Account: Type of Patient	Takes into Account: Skill Req.	Takes into Account: Quality A/D	Staffing Developed By: Ratio Hrs/Pat.	Staffing Developed By: Time Std's Equat.	Staffing Developed By: Evaluation Existing System	Ease of Manual Applied**	Can be Computerized	Ability to Evaluate Changes in Procedures**	Reflects Daily Workload Changes**	Ability to Predict Future Needs**	Work to Adapt to Military*
ALT. #1													
Air Force Work Center Manning Standards		x				x		1	x	1	2	2	0
Work Sampling	Depends on System Studied						x	3		1	0	2	2
ALT. #2													
The Johns Hopkins Criteria	x					x		1	x	1	2	2	1
ALT. #3													
Massachusetts Hosp. Assoc. NSMC	x	x		x	x			1	x	1	2	2	1
ALT. #4													
University of Michigan				x	x			1	x	1	2	2	3
ALT. #5													
"Graduate" Staffing	x	x	x	x	x	x		2	x	3	3	3	3

* 1 Poorest 2 Average 3 = Best
** 1 Easiest 2 Average 3 Most Difficult

[1] Refer to Volume IV State of the Art.

- Staffing: Was staffing developed by a ratio of nursing hours to patients, time standards or evaluation of the present system through use of work sampling.
- Ease of manual application.
- Can the system be computerized.
- Can the system predict future staffing needs.
- Can the system evaluate changes in Procedure - can it accurately determine what the effect of a change in dietary or pharmacy procedure will have on ward staffing.
- A comparison of the amount of work required to adapt to the military.

Organization

The five ward management organization alternatives were evaluated using the following eight criteria:

1. Personnel Control — does the organization structure permit management to exert strong control over ward personnel?
2. Personnel Friction -- an evaluation of the degree of friction between ward and ancillary personnel and between the various personnel on the ward, due to the staffing organization.
3. Personnel Tension -- an evaluation of the amount of tension developed in individual ward personnel.
4. Job Satisfaction -- a measure of the degree of job satisfaction ward personnel will have using each alternative.
5. Patient Care -- a subjective evaluation of the quality of patient care with this organization structure.
6. Quality of Administrative Functions -- an evaluation of how well the clerical/administrative functions are performed.

7. Ease of Implementation in BLHC System — an evaluation of the difficulty of getting the organizational structure to work smoothly in the military.
8. Overall Evaluation — an average evaluation of the alternative for the seven criteria presented above.

The results of these evaluations are shown on Table 3.3-30.

RECOMMENDATIONS

Staffing

The Westinghouse studies conducted at the three primary BLHC Systems indicate that staffing of the nursing service in the military is generally of such a high quality that opportunities for substantial improvement are difficult to identify; however, there are some areas for potential improvement.

As a result of the analysis of the staffing alternatives, the Westinghouse Study Team recommends the following:

1. Nursing procedure time values be developed for military hospitals by type of patient, level of patient dependency, and type of nursing skill required using the V.A. time values as a starting point and correlating these activities to military procedures.
2. The Westinghouse "Graduate" staffing procedure be implemented and computerized to enable the Chief of Nursing Service to vary unit staffs on a daily basis as the workload varies.
3. A staffing concept be adopted which employs a trained cadre of nursing personnel available for assignment to various units in response to peak workload demands.
4. Re-evaluated the skills needed to perform specific procedures.

TABLE 3.3-30

WARD MANAGEMENT ORGANIZATION ALTERNATIVES

Alternative	Personnel Control	Personnel Friction	Personnel Tension	Job Satisfaction	Patient Care	Quality of Admin. Funct.	Ease of Implementing in BLHCS	Overall Ranking
ALT. # 1 The Present Mil. Structure	4	4	3	2	2	2	5	3.2
ALT. #2 Conventional Unit Manager	2	2	2	3	3	4	3	2.8
ALT. #3 Area Unit Manager	2	2	2	3	3	4	3	2.8
ALT. #4 Nursing Specialists	3	2	3	4	4	3	3	3.2
ALT. #5 Modified Nursing Specialist - U.M.	4	4	4	5	5	4	4	4.3

Rating Scale Used is a 1 to 5 scale where 1 is Poorest and 5 is Best.

5. An effort be made to level the nursing workload during the day. This could be accomplished by rescheduling from the peak morning hours of 0700 - 1000 procedures such as:

- Inpatient movement to ancillary areas
- Admission/discharge for admissions other than morning sick call
- Bed baths
- Routine procedures such as medications and TPR's.

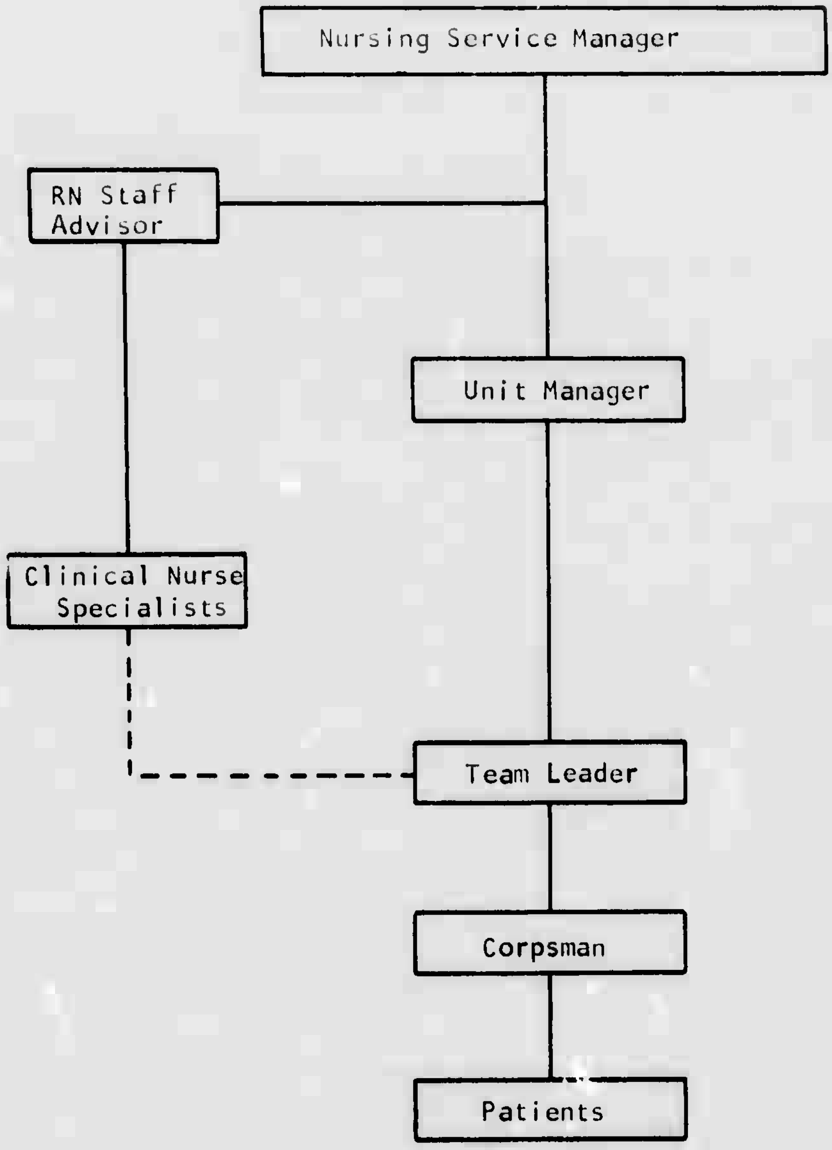
If rescheduling these and other similar nursing activities, the variation in workload in a 500 bed BLHCS can be reduced by only 25 percent, based on studies shown in Appendix II, Volume V Data Inventory, a savings of 10 ward personnel would be possible.

Organization

Westinghouse recommends the Modified Nursing Specialist-Unit Manager form of organization. Its break with the traditional approach is small enough to make it readily acceptable to all personnel, but large enough to accomplish the goals of improved organization. This alternative's major departure from present practice is the freeing of the nursing staff from administrative tasks, thus allowing them to concentrate on the delivery of patient care. The present NCOIC ward duties should be changed to those of a Unit Manager with responsibilities for all clerical and administrative duties. The Unit Manager would report to the Nursing Care Coordinator. The administrative functions now performed by the Nursing Supervisor should be performed by the Wardmaster (who presently reports to the Nursing Supervisor), thus enabling the Supervisor to function as a Nursing Specialist.

It is further recommended that following successful implementation of the Modified Nursing Specialist - Unit Manager organizational alternative

and when the nursing personnel are comfortable with the new concepts, that DoD consider further changes. Two recommended alternatives for the future are shown in Figures 3.3-50 and 3.3-50.1, however, DoD should base all changes on the state of the art at the time such change is contemplated.



* Capt. C. J. Schumaker Jr. USAF, MSC and Lt. M. J. Wood USAF, MSC, "Proposal for expanding unit-management Concept" Hospital Topics June 1970

FIG. 3.3-50 - EXPANDED UNIT - MANAGER CONCEPT*

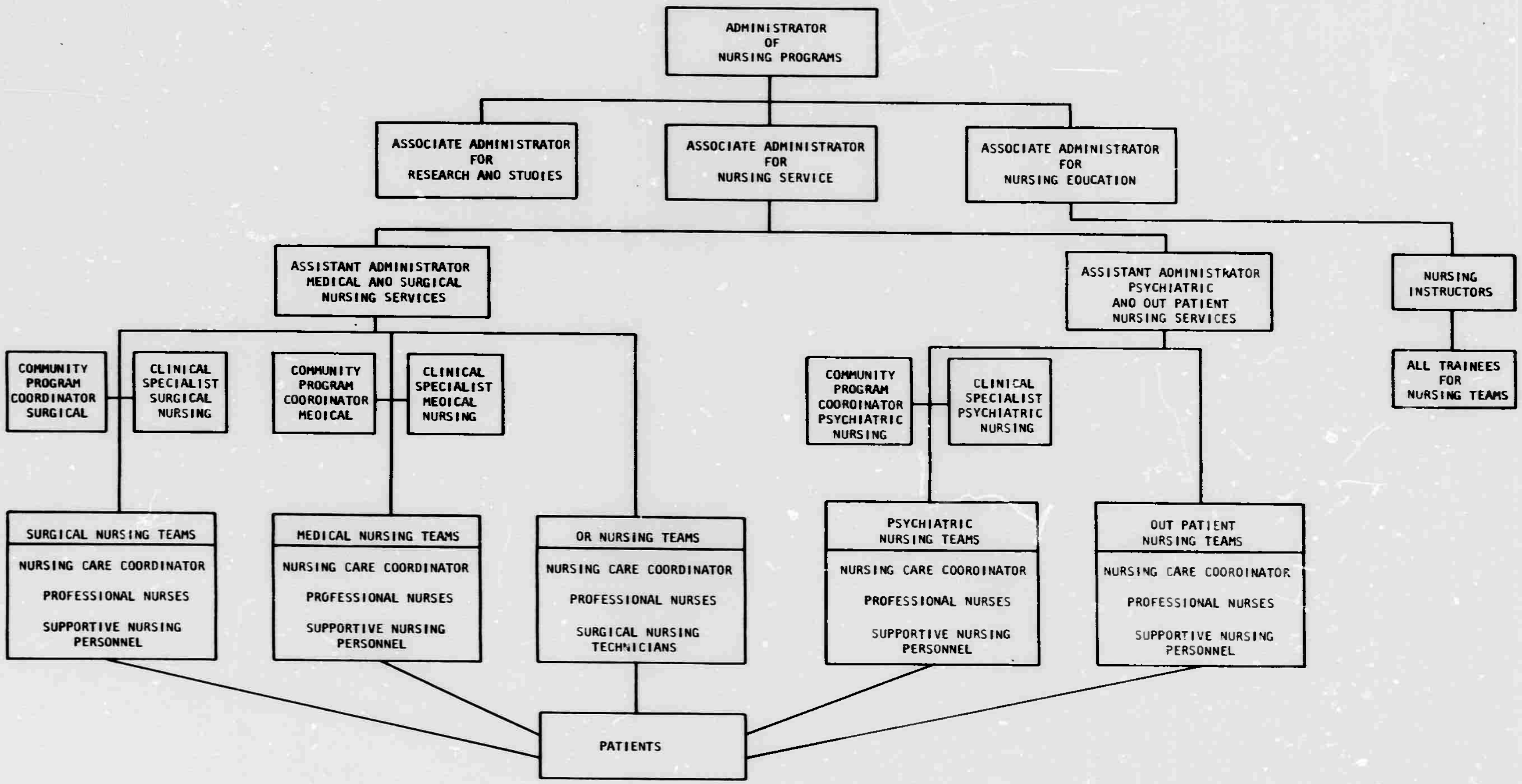


FIG. 3.3-50.1 - ORGANIZATIONAL CHART - NURSING SERVICE

EDUCATION AND TRAINING

Education and training programs in the BLHC System are usually aimed at personnel orientation, continuing education, or on-the-job training. A minor but increasingly important objective is to instruct patients and their families in preventive medicine and dentistry. The quality and scope of training is excellent.

Education and training is an important and continuing process in the BLHC System and one of the few areas where the effects of cost and inefficiency are not fully understood. Regardless of the professional level at which an individual enters the system, continuing education and training are essential if an individual's capabilities and potential are to be fully utilized.

Approximately fifty percent of all BLHCS education and training is on-the-job training. Typically, approximately sixty-three percent of Army and Navy hospital staff are receiving on-the-job training to prepare them for assignments to frontline or remote facilities. On-the-job training, however, demands considerable expenditure of both time and money, reduces teacher efficiency, and produces non-uniform instruction of a type that is particularly difficult to monitor.

Expanding patient care workloads coupled with staff shortages severely limit the time skilled and professional personnel can devote to education and training. The prime objective of the Westinghouse study, therefore, was to investigate methods by which these personnel could be relieved of repetitive training duties by increased use of electronic and mechanical devices.

Technical Approach

A three-phase technical approach was used for the study:

1. Education and training problems were identified by the data collection team at each of the three primary BLHC Systems.

2. Personal visits by Westinghouse Learning Corporation consultants were made to education coordinators, ward supervisors, NCO's, and other supervisory personnel. Thirty interviews were conducted at Beaufort, 45 at Andrews, and 60 at Dix to determine present methods and their effectiveness.
3. Initial research was undertaken including a review of military publications on training-related regulations, manuals, pamphlets, and instructions to develop a preliminary description of the current training procedures.

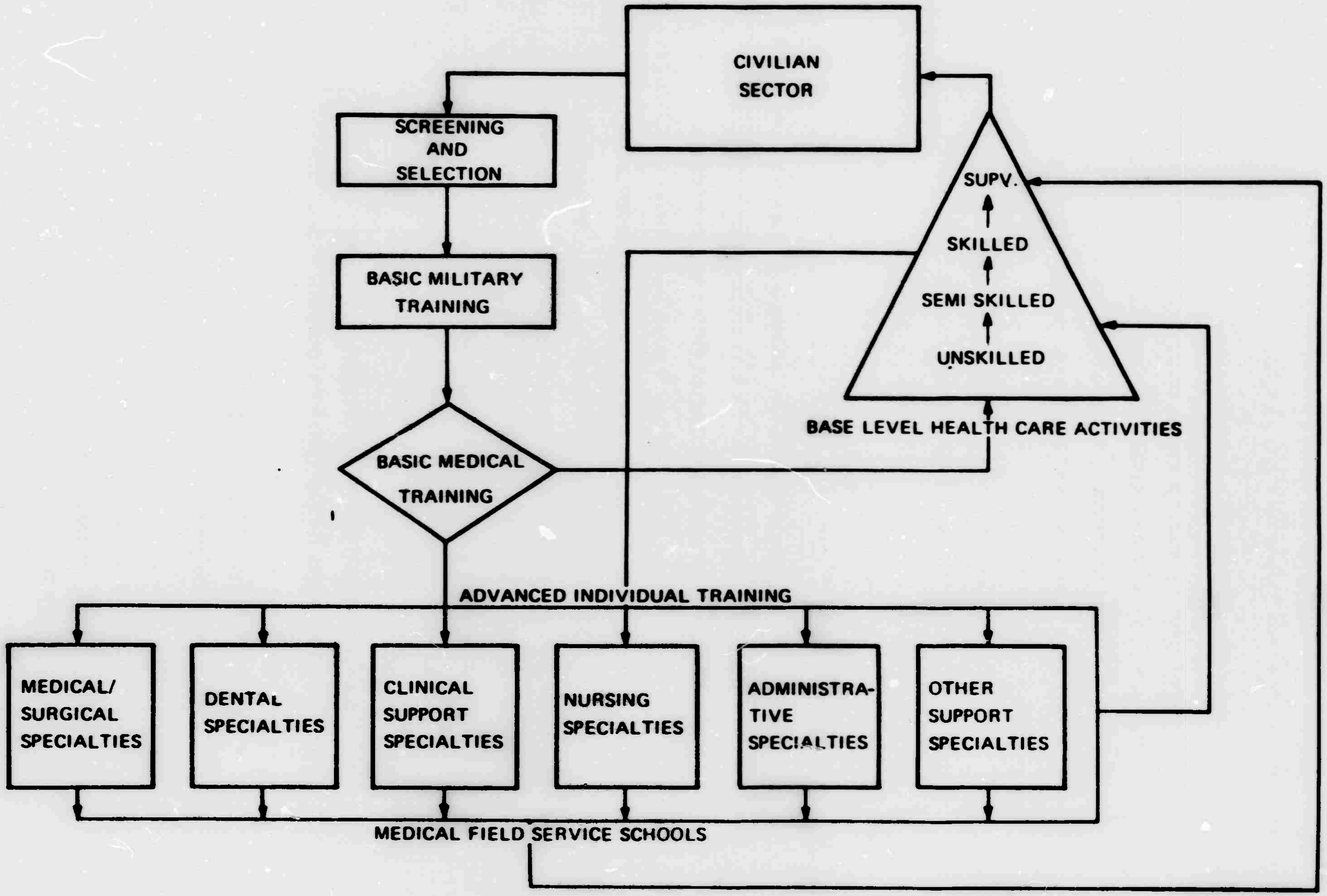
Present Alternative

In present BLHC Systems, education and training is primarily individualized on-the-job training (OJT); selected individuals also receive formal specialized training. A typical medical recruit goes through the training curriculum illustrated in Figure 3.3-51. Every recruit is given basic medical training after which thirty-five to fifty-five percent go directly to the BLHC System at unskilled levels. Forty-five to sixty-five percent progress to advanced individual training in Medical Field Service Schools, before entering the BLHCS at semi-skilled or skilled job levels. A small percentage are returned to the Medical Field Service Schools for further supervisory training.

BLHC System education and training programs are divided into four categories:

1. Orientation programs for all new personnel.
2. Continuing education for physicians and dentists, nurses, and administrators.
3. On-the-job training (OJT), the largest cost item, for all new corpsmen personnel as well as for continuous upgrading of all personnel.
4. Medical Field Service Schools for specialty training in medical, surgical, dental, clinical, nursing, administrative, and other support specialties.

FIGURE 3.3-51: FLOW OF PERSONNEL THROUGH MILITARY HEALTH SERVICES EDUCATION AND TRAINING SYSTEM



Improvement Alternatives

Five alternatives selected from the state-of-the-art survey warrant detailed analysis (See Appendix 3.3-3). The preliminary study however, indicated that none of the five alone had all the desired characteristics. Consequently, a sixth alternative was synthesized in an attempt to further meet the systems needs. A short description of the six alternatives follows:

Alt. #1 Programmed Instruction (PI) uses carefully controlled and sequenced stimuli designed to elicit responses from the student at a pace generally determined by the student. These stimuli can be presented either by a test-workbook method or by a teaching machine.

Branched sequencing programmed instruction was chosen for analysis because it allows the student to proceed along multiple paths. Information is presented and questions are asked; incorrect answers lead to additional instruction and explanation related to that question, while correct answers allow the student to proceed to the next question.

Alt. #2 Learner Centered Audio-Visual Devices present programs using a wide variety of methods including 35 mm motion pictures, single concept sound filmstrips, sound-on-slide presentations, and recordings. Learner Center devices with sound and filmstrip cartridges were chosen for analysis.

Alt. #3 Instructional Television can present programmed material in many forms including sound, print, picture, motion and live transmission or in partial modes such as audio or still pictures only. It may also be used as a transmitter to distribute and display data. Because there are no provisions for student feedback,television cannot be an interactive medium. Two particular forms of instructional television were chosen for analysis: video tape recording and playback (VTR); and closed circuit TV without feedback (CCTV-w/o FB).

Alt. #4 Dial Access Information Retrieval (DAIR) provides access to a central library of recorded programs for all personnel authorized to use the retrieval devices. Programs can then be displayed on a television screen,

projector, or audioplayback unit at any time merely by dialing an assigned telephone-type number for the desired program. Dial access with audio visual devices (DAIRS A/V) was chosen for analysis.

Alt. #5 A Combination of teaching machines with branching programming, combined with sound and motion pictures (TM-B-Snd-MP).

Alt. #6 Integrated Media which combines electronic dial access (VIDAC)--developed by the Westinghouse Learning Corporation and Newell Industries -- with instructional program management information and control. VIDAC is more compact, larger in instructional materials storage capability, and considerably less expensive than conventional dial access. A Westinghouse-developed disc scan converter and an electronic cross bar switcher permit rapid access to stored materials and even faster "dump time," during which the desired segment of instruction is duplicated in an intermediate buffer state, thus freeing the master storage discs for large numbers of almost simultaneous requests.

Conclusions

1. From the Westinghouse studies, it is apparent that BLHCS Education and Training processes involve almost all staff to some extent either as teacher or student. In some facilities, as many as two-thirds of the staff may be involved in on-the-job training.
2. "On-the-job training" (OJT) is the largest cost item at all three hospitals, ranging from 46 percent to 54 percent of total education and training cost; it is also the most susceptible to cost reduction. OJT is highly labor dependent--almost always on a one-to-one instructor-to-student basis. Teaching aids could free the instructor from some of the routine and repetitive teaching tasks, and enable the student to proceed more rapidly.
3. Present OJT methods utilizing staff as teachers has an unquantifiable impact on the effectiveness and efficiency of the staff in the performance of their regular duties.

4. Present OJT training method is difficult to monitor in terms of student progress and uniformity of quality of instructions.
5. None of the improvement alternatives identified in the state-of-the-art survey is capable of performing all the Education and Training functions, even at unreasonable cost levels, and none of the alternatives enabled personal instruction to be entirely eliminated.
6. The study team concluded that Alternative #6 -- "Integrated Media" offers the best potential in terms of lowest operating cost, scope of instructional programs, simplicity,flexibility, and effectiveness. These advantages outweigh the only major disadvantage -- the instructional program cannot be paced to the individual learner.
7. The predominant cost/benefit justification for Alternative #6 is based on a reduction in life cycle cost for the direct and identifiable costs of OJT training. Additional economics should derive from more effective utilization of staff freed from teaching duties.
8. The media used in Alternative #6 is suitable for use in several fields of Education and Training other than on-the-job training, thus resulting in further cost savings. For example, the system can be interfaced with reference data and research data banks, distributing these data more fully throughout the hospital.

Recommendations

1. Westinghouse recommends that all new BLHC Systems be designed and equipped for Alternative #6 -- "Integrated Media"-- since studies have shown savingsin the order of 30 percent to 44 percent of the total Education and Training cost, depending on the size and scope of the BLHC System.
2. Design and staffing criteria should be revised to accommodate the "integrated media" approach.
3. An analysis should be undertaken to determine the feasibility of installing the "integrated media" system in existing BLHC Systems.

Evaluation Assumptions

Functional costs associated with Education and Training at the three primary study BLHCS were broken down by activity and by personnel and non-personnel categories, as shown on Tables 3.3-31, 32 and 33.

1. Personnel costs include instructor and trainee time multiplied by an average rate for the three hospitals and does not include the cost of the service component involved, i.e. patient care delivery.
2. Non-personnel costs include learning materials, their development and periodic updating or revision, and initial and operating costs of equipment and facilities.

Costs at Beaufort, Andrews, and Dix were projected to "typical" 250-, 500-, 750-, and 1000-bed hospitals, using the following cost factors:

1. Staff size was compared to number and percent of staff in training on Table 3.3-34. Beaufort and Dix averaged 63 percent of total staff in training at any one time, while Andrews averaged only 29 percent. This large variation is attributed both to the two year tour of duty in the Air Force and the policy of keeping corpsmen in the system throughout their tour of duty, while the Army and Navy transferred trained corpsmen to the field more quickly.
2. Table 3.3-35 shows instructor and trainee hours devoted to OJT by function as well as hours of instruction and hourly rate of pay averaged over the three study hospitals. Total personnel (OJT) costs for four typical hospital sizes is shown on Table 3.3-36 and plotted on Figure 3.3-52.
3. Learning materials and equipment requirements will vary with hours of instruction required within each functional area. Table 3.3-37 lists the major functions together with the Westinghouse estimate of the instructional needs for each major function based on the data gathered and surveys performed (aggregating eight categories of instructions under Ward Management and three under Dental Clinics.) The OPD estimate assumes a scale relationship in the number of departments as related to size of hospital and assumes 12, 15 and 18 departments

Table 3.3-31: Functional Cost of Education and Training - Beaufort Naval Hospital

Functional Areas / Cost Categories	Ward Mgmt	Outpatient Depts.	Clinical Labs	Radiology	Pharmacy	Registrar	Medical Records	Dietary Dept.	Dispensaries	Dental Clinics	Sub-Total	Totals
In-Service Programs	$30,669	$10,722	$23,370	$3,754	$1,111	$1,034	$149	$1,251	$41,064	$20,250		$133,374
Formal Instruction	11,390	7,647	1,039	413	599	94	---	67	20,979	2,256	$44,484	
Lectures	180	270	10	20	20	10	---	10	---	---	520	
On-The-Job Training	19,099	2,805	22,321	3,321	492	930	149	1,174	20,085	17,994	88,370	
Instructor Costs	12,243	1,845	12,457	2,044	276	503	80	661	10,536	12,562	53,207	
Trainee Costs	6,856	960	9,864	1,277	216	427	69	513	9,549	5,432	35,163	
Special Programs	---	---	---	---	---	---	---	---	---	---		---
Professional Education	---	---	---	---	---	---	---	---	---	---	---	
Residency Programs												
Internship Programs												
Other												
Technical & Support Training	---	---	---	---	---	---	---	---	---	---	---	
Training Related TDY	$1,010	$ 832	210	105	210	---	---	105	802	1,200		$ 4,474
Support Requirements	$ 8,771	$3,415	1,501	151	362	620	77	465	8,999	305		
Staff	8,346	3,225	1,354	406	347	620	77	465	8,944	155		$24,969
Medical Education	---	1,752	192	96	192	---	---	---	---	---	2,232	
Nursing Service	5,246	---	---	---	---	---	---	---	---	---	5,246	
Enlisted Training	3,100	1,473	1,162	310	155	620	77	465	8,944	155	16,461	
Materials, Equipment & Facilities	425	190	150	45	15	---	---	---	55	150		
TOTAL ANNUAL COST	$40,450	14,969	25,084	4,310	1,683	1,654	226	1,821	50,865	21,755		$162,816

Table 3.3-32: Functional Cost of Education and Training - Malcolm Grow USAF Medical Center

Cost Categories \ Functional Areas	Ward Mgmt	Outpatient Depts.	Clinical Labs	Radiology	Pharmacy	Registrar	Medical Records	Dietary Dept.	Dispensaries	Dental Clinics	Sub-Total	Totals
In-Service Programs	$60,178	$45,827	$12,934	$15,311	$3845	$24,527	$720	$6519	$ 983	$50,716		$221,560
Formal Instruction Lectures	17,155	23,122	4,324	3,772	-0-	-0-	-0-	-0-	-0-	9,532	$57,905	
On-The-Job Training	43,023	22,705	8,610	11,539	3845	24,527	720	6519	983	41,184	163,655	
Instructor Costs	14,690	5,420	3,398	1,533	839	2,452	124	920	315	7,775	37,466	
Trainee Costs	28,333	17,285	5,212	10,006	3006	22,075	596	5599	668	33,409	126,189	
Special Programs	-0-	26,600	45,044	3,440	-0-	-0-	-0-	917	-0-	17,328		$93,329
Professional Education	-0-	17,773	-0-	-0-	-0-	-0-	-0-	917	-0-	17,328	36,018	
Residency Programs	-0-	5,833	-0-	-0-	-0-	-0-	-0-	-0-	-0-	7,777	13,610	
Internship Programs	-0-	11,940	-0-	-0-	-0-	-0-	-0-	917	-0-	9,552	22,409	
Other	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	
Technical & Support Training	-0-	8,827	45,044	3,440	-0-	-0-	-0-	-0-	-0-	-0-	57,311	
Training Related TDY	$10,826	$8,331	5,422	4,396	-0-	-0-	-0-	1611	761	8,716		$40,063
Support Requirements												
Staff	$15,160	$5,612	3,170	827	606	692	476	908	5320	7,173		$39,944
Medical Education	-0-	1,922	229	178	-0-	-0-	-0-	-0-	-0-	2,329	4,658	
Nursing Service	9,754	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	9,754	
Enlisted Training	5,406	3,690	2,941	649	-0-	692	476	908	5320	4,844	25,532	
Materials, Equipment & Facilities												
TOTAL ANNUAL COST	$86,164	86,370	66,570	23,974	4,451	25,219	1196	9955	7064	83,933		$394,896

Table 3.3-33: Functional Cost of Education and Training - Walson Army Hospital

Cost Categories / Functional Areas	Ward Mgmt	Outpatient Depts.	Clinical Labs	Radiology	Pharmacy	Registrar	Medical Records	Dietary Dept.	Dispensaries	Dental Clinics	Sub-Total	Totals
In-Service Programs	$166,050	$75,025	$20,369	$8,321	$ 7315	$ 4703	$7473	$5205	$10,629	$68,066		$373,156
Formal Instruction Lectures	58,061	14,621	2,255	1,546	-0-	-0-	-0-	-0-	-0-	35,843	$112,326	
On-The-Job Training	107,989	60,404	18,114	6,775	7315	4703	7473	5205	10,629	32,223	260,830	
Instructor Costs	29,533	11,211	9,154	2,088	783	1898	3938	1819	3,499	12,902	76,825	
Trainee Costs	78,456	49,193	8,960	4,687	6532	2805	3535	3386	7,130	19,321	184,005	
Special Programs	20,800	20,162	-0-	5970	-0-	-0-	-0-	-0-	-0-	16,482		$ 63,414
Professional Education												
Residency Programs	-0-	19,106	-0-	-0-	-0-	-0-	-0-	-0-	-0-	16,482	35,588	
Internship Programs	-0-	-0-	-0-	5,970	-0-	-0-	-0-	-0-	-0-	-0-	5,970	
Other	20,800	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	20,800	
Technical & Support Training	-0-	0,056	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	1,056	
Training Related TDY	---	---	---	----	---	---	---	---	---	---		---
Support Requirements	$ 30,016	$15,504	2,574	2508	1136	284	1080	853	2,387	2,330		$ 58,672
Staff												
Medical Education	-0-	2,000	131	65	-0-	-0-	-0-	-0-	-0-	-0-	2,196	
Nursing Service	18,766	4,356	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	23,122	
Enlisted Training	11,250	9,148	2,443	2,443	1136	284	1080	853	2,387	2,330	33,354	
Materials, Equipment & Facilities												
TOTAL COST	$216,866	110,691	22,943	16,799	8451	4987	8553	6058	13,016	86,878		$495,242

TABLE 3.3-31. Staff: Patient Trainee Ratios for Three Primary Study Hospitals

BLHCS	Bed Capacity	Occupied Beds	Percent Occupancy	Numbers of Staff	Staff in Training	Percent in Training
Beaufort	280	200[1]	.71	555	350	.63
Andrews	350	297[2]	.84	1098	319	.29
Dix	750 (9 mos) 1000 (3 mos) $\bar{x}$ 812.5	668[3]	.82	1447	924	.63
Composite	1442.50	1165	.79	2600	1593	.51

Staff: Patient Ratio (Actual)

B	555 : 200	(2.77)
A	1098 : 297	(3.69)
D	1447 : 668	(2.16)
	Composite	2.87

Staff: Patient Ratio (Cap)

B	555 : 280	(1.98)
A	1098 : 350	(3.13)
D	1447 : 812.5	(1.78)
	Composite	2.29

Sources

1. Beaufort Study Team
2. Andrews Data Pack, Table 6. (Biometric Division Report)
3. Dix Data Pack (FY 68) (Neurological, Surgical, Medical Division Reports)

TABLE 3.3-35. Composite Summary of Average Trainee Hours, Average Instructor Hours, and Average Hourly Wage Rates Based on Data Collected at the Three Primary Hospitals

Functional Areas	Number of Trainees	Hours Spent in Training	Trainee Hourly Rate	Hours of Actual Instruction	Instructor Hourly Rate
Ward Management	618.10	61.90 hrs	$ 2.90	17.73 hrs.	$ 5.19
Outpatient Dept.	317.50	77.59	3.06	13.08	4.99
Laboratory	101.5	91.33	2.73	58.96	4.26
Radiology	39.60	158.98	2.67	35.96	4.24
Pharmacy	29.80	176.79	2.13	14.71	4.51
Registrar	70.00	165.01	2.69	17.58	3.90
Records	41.00	53.25	2.41	22.90	5.47
Dietary	97.80	36.74	2.51	9.35	3.71
Dental	339,8	79.07	2.79	18.33	5.63
Dispensaries	288.3	23.97 hrs.	$2.60	15.55 hrs.	$ 3.24
$\bar{x}$	1943.40	69.38	2.79	18.91	4.75

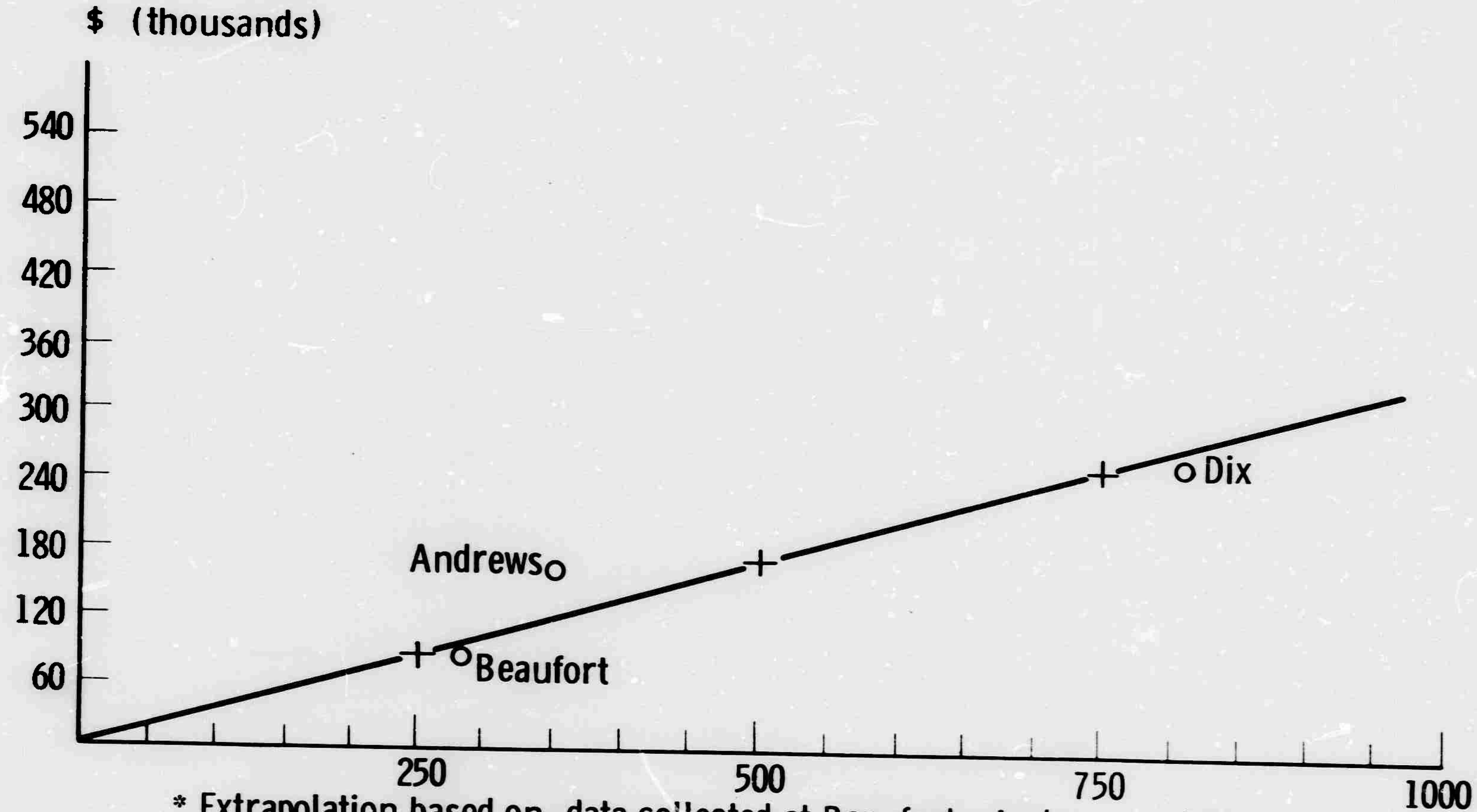
TABLE 3.3-36. Staff Size, Instruction Hour Requirements, and Summary Costs for "Typical" Military Hospitals.

Beds	Staff (1)	TRAINEE COSTS				INSTRUCTOR COSTS			Total Cost
		Number of Trainees (2)	Trainee Hours	Trainee Hourly Rate	Cost	Instructor Hours	Instructor Hourly Rate	Cost	
250	572.5	292	69.38 hrs	$2.79	$ 56,522	18.91 hrs	$ 4.75	$ 26,228	$ 82,750
500	1145	584	69.38	2.79	113,045	18.91	4.75	52,456	165,501
750	1717.5	876	69.38	2.79	169,567	18.91	4.75	78,685	248,252
1000	2290	1168	69.38	2.79	226,090	18.91 hrs	$4.75	$ 104,913	$331,003

(1) Based on a 2.29:1 Staff:Patient Ratio

(2) Based on .51:1 Trainee:Staff Ratio

(Averages obtained from data collected at Three Primary Study Hospitals)



* Extrapolation based on data collected at Beaufort, Andrews and Dix in October, November, and December, 1969

Fig. 3.3-52 —On-the-job training costs for 250, 500, 750 and 1000 bed military hospitals *

FUNCTIONAL AREAS	Hours of Instruction Required	Hours of Materials Required	MATERIALS DEVELOPMENT REQUIREMENTS			
			250	500	750	1000
Ward Management (1)	18	9	72 hrs.	72 hrs.	72 hrs.	72 hrs.
Outpatient Depts (2)	13	6.5	78	97.5	117	136.5
Clinical Laboratory	59	30	30	30	30	30
Radiology	36	18	18	18	18	18
Pharmacy	15	7.5	7.5	7.5	7.5	7.5
Registrar	18	9	use medical records materials			
Medical Records	23	11.5	11.5	11.5	11.5	11.5
Dietary	9	4.5	4.5	4.5	4.5	4.5
Dental Clinics (3)	18	9	18	18	18	18
Dispensaries	16	8	use ward mgmt /OPD materials			
TOTAL HOURS	225	113	239.5	259.0	278.5	298.0
NUMBER OF 10 MINUTE A/V PROGRAMS			1437	1554	1671	1688

TABLE 3.3-[illegible]. Learning Materials Development Requirements

for 250-, 500- and 750-bed hospitals, respectively. Total instructional hours needed are converted to number of ten-minute audio visual programs by multiplying instructional hours by six. Equipment requirements depend upon the number of terminals or consoles (TV monitors) needed to provide access to programs stored in a central data bank, and the size of the data bank. The number of terminals required depends upon number of trainees, their distribution among the ten functions, the proximity of work units within each area, and peak utilization time. The size of the data bank was determined by assuming that one tape deck (video tape recorder) can store 300 ten-minute audio-visual programs.

The above data quantifies cost in terms of the estimated manpower and materials required for the typical BLHC System to properly perform the full array of on-the-job training. For each improvement alternative, similar estimates were generated to define cost in terms of manpower and equipment required to provide the same education and training. Where an alternative did not have the full capability, its costs were increased by a Westinghouse estimate of that portion of the need unfilled and which would have to be performed at the same cost as the present method.

Evaluation Criteria

Each improvement alternative was evaluated for:

1. Flexibility-- Defined by the alternative's ability to provide stimulus encoding forms.
2. Learner-pacing -- Can the student proceed as quickly as his talents and time allow?
3. Group-scheduling -- Can the alternative teach more than one student at a time?

4. Interaction--Can the student respond to instructional stimuli?
5. Adaptability--The extent to which an alternative can be effectively substituted for an instructor; 0 to 33 percent is limited effectiveness, 33 to 66 percent, moderate, above 66 percent, high. No alternative completely eliminates instructors.
6. Acceptability--Preferences of the student population, based on a previous Westinghouse survey of 750 hospitals throughout the United States.
7. Accessibility--Is the programming material continuously available at convenient locations?

Cost/Benefit Analysis

The five most promising improvement alternatives which resulted from a preliminary review of the state-of-the-art data, plus the "Integrated Media" approach were evaluated in greater detail for cost justification and then compared with additional subjective criteria. The results of this evaluation are shown on Tables 3.3-38 and 39. The cost sensitivity indices of each medium are also shown. (The higher the indicator, the more favorable the cost sensitivity of the media, that is, the larger the economies of scale to be realized by increasing either the student load, the course duration, or both).

From this analysis, "Integrated Media" was shown to be the most likely improvement alternative. A further detailed analysis was performed comparing costs and benefits of this alternative to the present system. The results of this cost analysis is shown on Table 3.3-40. Tables 3.3-41 and 42 contain additional cost data used in this analysis.

Present Value Costs over a 20-year Life Cycle were calculated for each of these two methods for a 500-bed hospital. The evaluation assumptions used were: 10 percent discount rate; 4 percent inflation rate for both personnel and operating costs; and 5 percent inflation rate for program revision costs. Programs were assumed to have a useful life of 10 years; equipment a useful life of 20 years; annual maintenance costs, equal to 5 percent of initial

MEDIA	STIMULUS ENCODING FORMS					LEARNER PACED	GROUP SCHEDULED	INTERACTIVE	NON-INTERACTIVE	LEARNING MATERIALS PRODUCTION COSTS	LEARNING MATERIALS COST SENSITIVITY INDEX	SUMMARY STUDENT HOUR COST	SUMMARY COST SENSITIVITY INDEX
	VERBAL		PICTORIAL										
	AURAL	WRITTEN	STILL	MOTION	SYMBOLIC								
PI (B)		X	X		X	X		X		$ .85	3.5	$ .97	1.12
LCD(Snd FS Cart)	X	X	X		X	X			X	2.86	0.6	16.25	0.002
CCTV (w/o FB)	X	X	X	X	X	⊖	X		X	2.23	5.5	2.37	1.09
DAIRS (A/V)	X	X	X	X	X	⊖	X		X	.98	2.4	1.33	1.11
TM (B Snd MP)	X	X	X	X	X	X		X		13.68	N/A	66.94	N/A
INTEGRATED MEDIA	X	X	X		X	⊖	X		X	1.01	1.1	1.63	1.242

TABLE 3.3-38. Comparative Capabilities, Costs and Cost Sensitivities of Selected Media.

⊙ Random dial access permits learner paced utilization of video tape based CCTV systems.

Table 3.3-39. Summary Comparison of Selected Media in Terms of Overall Suitability for BLHCS Applications.

MEDIA	COSTS *			ADAPTABILITY						
				IN SERVICE PROGRAMS		SPECIAL PROGRAMS				
	INITIAL	OPERATING	SENSITIVITY TO CHANGE	FORMAL INSTRUCTION	ON-THE-JOB TRAINING	PROFESSIONAL EDUCATION	TECHNICAL AND SUPPORT TRAINING	PATIENT EDUCATION	ACCESSIBILITY	ACCEPTABILITY
PI (B)	$ .21	$ .76	1.120	mod	lim	lim	mod	lim	lim	mod
LCD(Snd FS Cart)'	13.70	2.55	0.002	mod	lim	mod	mod	mod	mod	lim
CCTV	.49	1.88	1.090	hi	mod	mod	mod	mod	mod	mod
DAIRS	.16	.57	1.11	mod	mod	mod'	mod	mod	hi	mod
TM (B Snd MP)	52.33	15.02	N/A	mod	mod'	mod	mod	hi	mod	hi
INTEGRATED MEDIA	1.16	.47	1.242	hi	mod'	mod'	mod	mod	hi	hi

* Per student hour based on an average student load of 600 students for 450 hours.

COST ELEMENTS (dollars/year)	CONVENTIONAL APPROACH				INTEGRATED MEDIA			
	250 beds	500 beds	750 beds	1000 beds	250 beds	500 beds	750 beds	1000 beds
Personnel								
Instructors	$26,228	$ 52,456	$ 78,685	$104,913	$13,144	$26,228	$ 39,343	$52,457
Trainees	56,522	113,045	169,567	226,090	28,261	56,523	84,784	113,045
Total Personnel	82,750	165,501	248,252	331,003	41,405	82,751	124,127	165,502
Materials								
Revision & Updating (20% per yr)	---	---	---	---	27,590	29,837	32,083	34,330
Equipment								
Operations & Maintenance (5% per year)	---	---	---	---	2,750	3,170	3,715	3,835
Total Non-Personnel	---	---	---	---	30,340	33,007	35,798	38,165
TOTAL COST	$82,750	165,501	248,252	331,003	71,745	115,758	159,925	203,667
Potential Savings (Percentage)					13.3%	30.1%	35.6%	38.5%

Table 3.3-10. First Year Cost Comparisons: Conventional vs Recommended Instructional Systems

FUNCTIONAL AREAS	TELEVISION MONITOR REQUIREMENTS			
	250 Beds	500 Beds	750 Beds	1000 Beds
Ward Management	4	6	8	10
Outpatient Dept	4	5	7	8
Clinical Laboratory	2	2	3	3
Radiology	2	2	2	2
Pharmacy	1	1	1	1
Registrar	1	1	1	1
Medical Records	1	1	1	1
Dietary	1	2	2	3
Dental Clinics	1	2	3	4
Dispensaries	1	2	3	4
TOTALS	18	24	[illegible]1	37
Number of 10-Minute Program to be Stored	1437	1554	1671	1683
Tape Deck Requirements	5	6	6	6

Table 3.3-41. Television Monitor and Tape Deck Requirements for Alternative 6 - Integrated Media.

COST ELEMENTS	INITIAL COST FOR EACH HOSPITAL ($)			
	250 Beds	500 Beds	750 Beds	1000 Beds
Materials Development @ $576/hr	$137,952	149,184	160,416	171,648
Scan Converter @ $8000 ea.	16,000 (2)	16,000 (2)	24,000 (3)	24,000 (3)
Terminals @ $400 ea.	7,200 (18)	9,600 (24)	12,000 (30)	14,400 (36)
Cross Bar Switches @$900 ea (12 x 5)	1,800 (2)	1,800 (2)	2,700 (3)	2,700 (3)
Tape Decks @ $6000 ea.	30,000 (5)	36,000 (6)	36,000 (6)	36,000 (6)
TOTAL EQUIPMENT	55,000	63,400	74,700	77,100
Installation @ 10% of Equipment	5,500	6,340	7,470	7,710
Total Initial Investment	$198,452	218,924	242,586	256,458

Table 3.3-12. Total Initial Investment in Materials and Equipment for Alternative 6 - Integrated Media

investment for equipment. These results are:

	20-Year Present Value Cost*
Conventional	$2,332,204
Integrated Media	$1,953,399

This represents a savings in present value dollars of $378,805 if the "Integrated Media" system is used in the above hospital in place of the current system.

*See page 3.3-8 and 9.

PHARMACY

Introduction

Drug distribution demands in the Pharmacy Departments of each of the three primary study hospitals varied considerably according to patient age, diagnosis, and type of medical staff. To determine the appropriate method of drug distribution, Westinghouse considered the following factors:

- How a drug's physical characteristics affect its mode of transportation
- Pricing policies
- How facilities and personnel affect drug administration
- Changes in the roles of paramedical personnel.

Pharmacy typically represents about 6 percent of a BLHC System operating budget. Of Pharmacy's budget, 17 percent represents personnel costs; 80 percent drug costs; and 3 percent supply costs.

TECHNICAL APPROACH

Characterization of Present System

The actual operation of BLHC pharmacies was characterized by work sampling and observation. The results of these studies are detailed in the Data Inventory volume. Figures 3.3-53 and 54 show the typical hourly pharmacy activities for Beaufort Naval Hospital and Walson Army Hospital. Both show comparable peaks of prescription filling workload between 0930 to 1100 and 1400 to 1530. This also coincides with a peak in both the number of outpatients waiting (Figure 3.3-55) and an increase in the length of prescription processing time (Figure 3.3-56).

Beaufort and Walson showed expected nonproductive peaks between 0800 and 0930 and at lunch time. Nonproductive time at Walson also peaked at the end of the day. This peak was not observed at Beaufort, although the study period at Beaufort was shorter than at Walson.

At both Beaufort and Walson, most of the housekeeping activities were performed in the late afternoon.

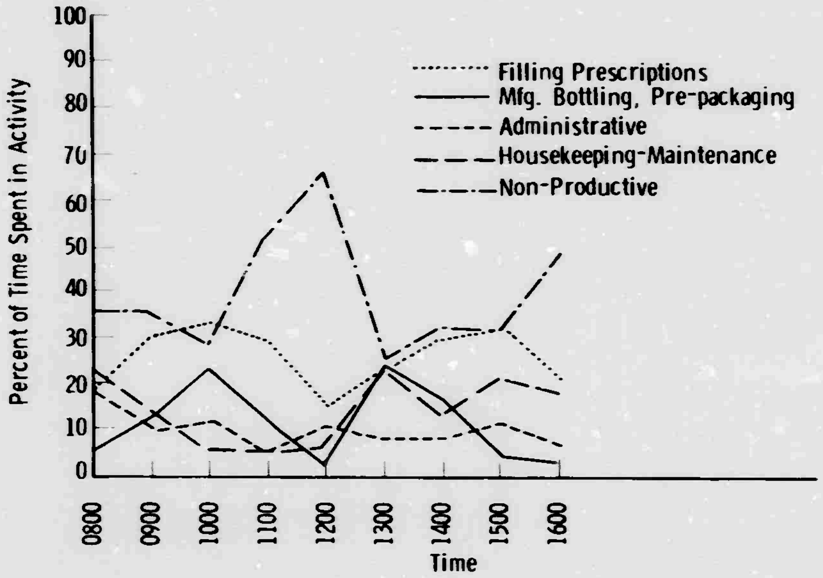


Fig. 3.3-54 —Pharmacy personnel utilization—Walson Army Hospital

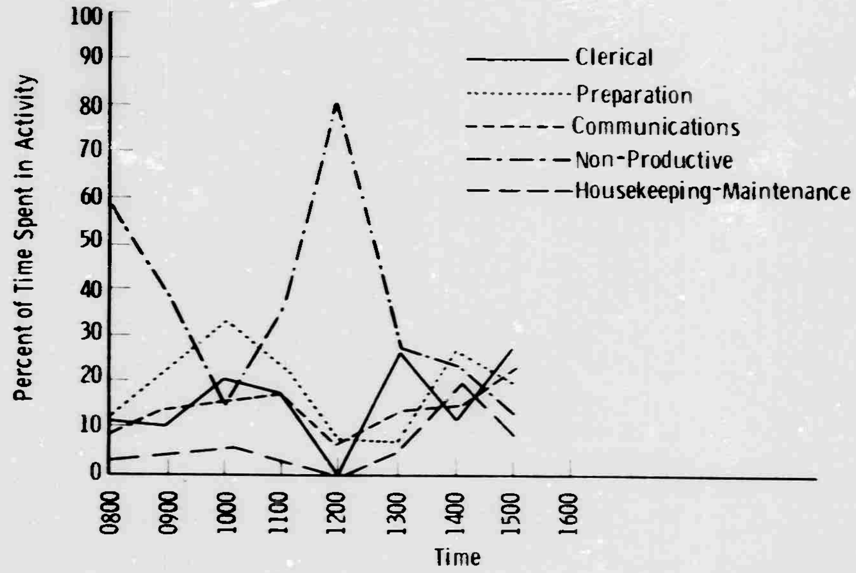


Fig. 3.3-53 —Pharmacy personnel utilization—Beaufort Naval Hospital

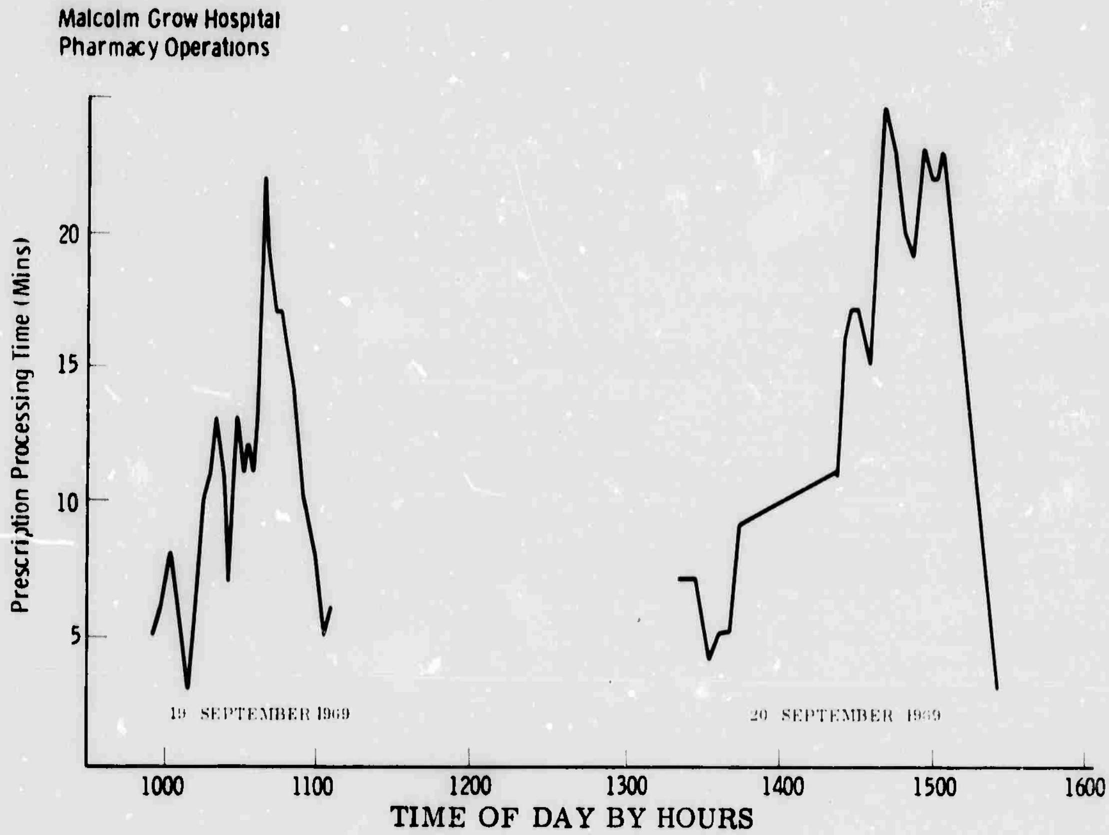


FIG. 3.3-55 — PROCESSING TIME

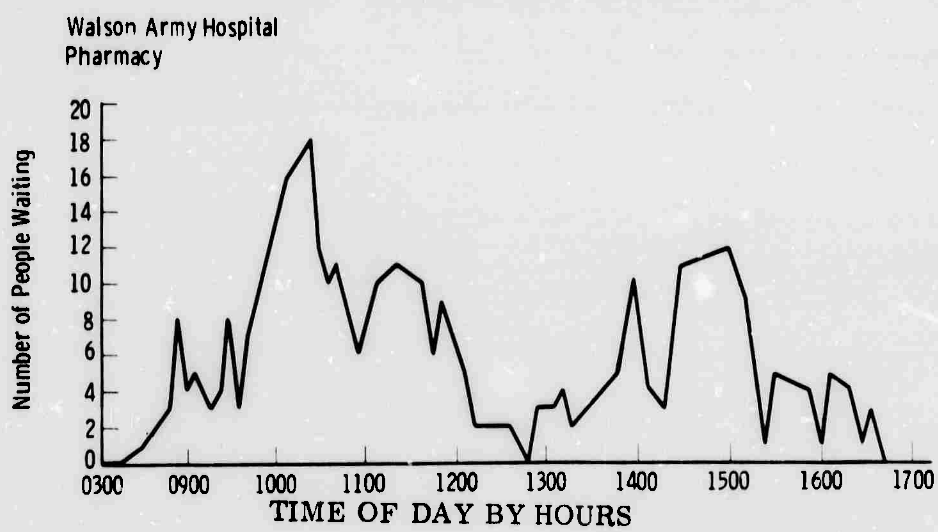


FIG. 3.3-56 - OUTPATIENT WAITING DISTRIBUTION - SEPTEMBER 30, 1969[5]

The outpatient Pharmacy operation at Malcolm Grow is typical of the three BLHC systems studied and is illustrated in Figure 3.3-57.

BLHC pharmacists currently perform most of the tasks related to drug distribution. Exact statistics on pharmacy manpower are difficult to determine, however, because of the various classifications and theoretical functional differences between civilian, commissioned, and enlisted pharmacists.

The basic drug distribution procedure for inpatient areas consists of the nurse or ward secretary interpreting and transcribing the physician's medication order and sending a requisition to pharmacy where the order is filled. The drug is delivered to the ward for storage on the nursing unit and administered until depletion, at which time the requisitioning procedure is repeated. Drug distribution for outpatient demands are typically responses to individual prescriptions presented in person by the patient at the pharmacy.

IMPROVEMENT ALTERNATIVES

On the basis of data collected during this study, the following ten improvement alternatives for Pharmacy have been selected for detailed analysis. Alternatives 1 through 4 are total distribution methods capable of handling all the needs of the BLHC System; alternatives 5 through 10 are auxiliary methods which can be used in conjunction with any of alternatives 1 through 4.

Total Distribution Alternatives

Alternative #1. Ward Component Drug Distribution uses a combination of the individual prescription order and the complete floor stock methods. This most nearly represents the present method of operation at the BLHC System. Individual prescription orders are the primary means for dispensing the most commonly ordered oral medications. Other drugs, including most injectables, narcotics, hypnotics, diagnostic drugs, ophthalmics, topicals, and PRN drugs are stocked on the ward. If properly balanced, the best features of the individual prescription order and ward stock methods may be realized.

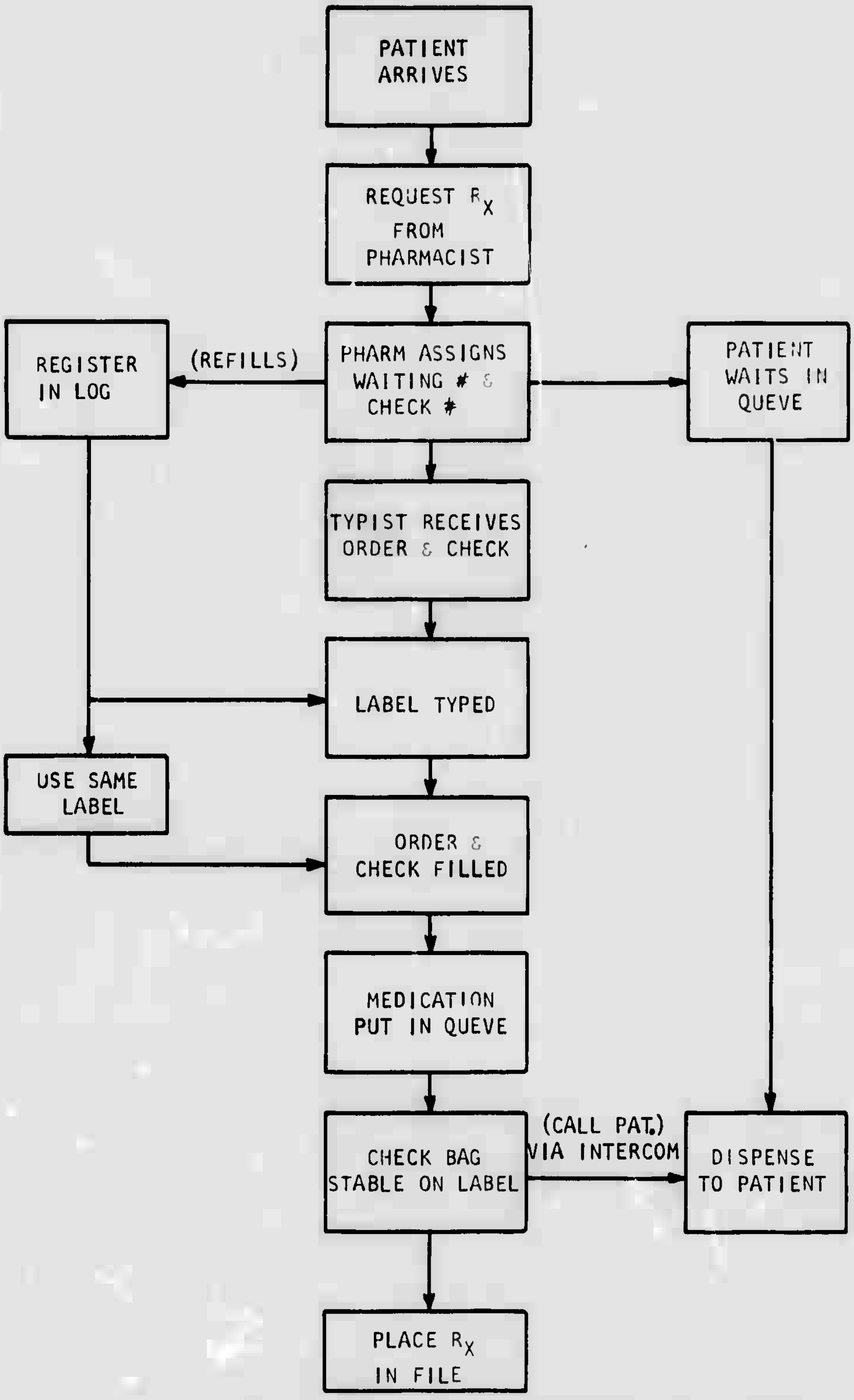


FIGURE 3.3-57. FLOW CHART OF DISPENSING OF PHARMACEUTICALS TO OUTPATIENTS -- MALCOLM GROW HOSPITAL.

Alternative #2. The Unit Dose Drug Distribution method combines three procedures:

(1) Distribution of scheduled medications prepared centrally and delivered periodically to the ward unit by medication carts. Deliveries are arranged by patient bed. Each card contains all medications scheduled for administration during that period.

(2) Automatic daily replacement of bulk items and miscellaneous drugs and supplies with packaging based on need and convenience.

(3) Locating clinical pharmacists in the patient care area to supervise a pharmacy service to the patients, coordinate medication activity with nursing personnel, and consult with the medical and nursing staff regarding drugs and drug therapy.

Alternative #3. The Mechanical Distribution method which uses mechanical dispensing devices to replace the traditional drug cabinet and medication room. A good example of this type of system is the "Brewer System" marketed by the Brewer Corporation. This system includes mechanical dispensing devices, medication delivery carts, and prepackaging equipment and materials. On receipt of an order, the nurse inserts plastic cards containing her authorization, the patient's name, and the drug name. The machine releases the drug, in predetermined quantities, produces a label carrying the patient's name, and creates billing tape for accounting and drug control. The present equipment is designed primarily to dispense oral solids such as tablets and capsules. Equipment capable of handling other dosage forms should be available by 1975.

Alternative #4. The Automated Drug Distribution method extends mechanical dispensing to interface with an automated hospital information network. Initiated through the hospital information network, automated drug distribution will automatically check the patient, drug, dose, route, schedule, duration, accounting, and drive control procedures using service drug formulary. The corrected order will be transmitted to a smaller

computer interfaced with mechanical dispensing devices which will calculate and schedule the dosage and eject the drug into a patient tray. This alternative will not be operational until the 1980's.

Auxiliary Alternatives

Alternative #5. The IV Additives Program concerns only intravenous fluids with medications added. To ensure adequate sterility, formulation, and stability, most IV solutions containing additives will be prepared centrally in the pharmacy and delivered to wards for administration.

Alternative #6. The Clinical Pharmacy Concept, originally tied with the unit dose drug distribution, can be extended and applied to other distribution alternatives. In addition to supervising all pharmacy services to patients, the clinical pharmacist would periodically check all patient medication profiles for incompatibilities, interactions, and dubious therapy, as well as coordinate and participate in clinical research studies and drug control programs.

Alternative #7. The Drug Information Center, as part of the pharmacy department, improves drug therapy both through direct support to various hospital committees and programs and through indirect support via the clinical pharmacist. Under the control of a pharmacist with special training in clinic investigation, statistics, pharmacology, and information science, the center is supported by selected texts, abstract services, and periodicals plus computer-assisted programs for data collection and distribution.

Alternative #8. Pharmacy Prescribing is an extension of the functions previously delegated to the clinical pharmacist. The pharmacist makes medical rounds with the physician and after the physician makes a diagnosis, the pharmacist prescribes the correct medication as indicated by the diagnosis.

Alternative #9. Pharmacy Medication Administration gives the pharmacy department the responsibility for all activities involving drugs, purchasing, preparation, delivery, and administration. Specifically, the clinical pharmacist will supervise the administration of all drugs by medication technicians, freeing nurses for activities more oriented toward patient care.

Alternative #10. Automated Outpatient Dispensing can probably be developed within the controlled environment of the outpatient clinic of a health care facility. After input of patient and prescription information on a computer terminal, the equipment will produce a label; management statistics; drug control data; inventory control and purchasing data; refill prescription information and dispense the drug to the patient.

Table 3.3-43 provides further general data on each alternative including availability; the changes which DoD must make in its present guidelines to accommodate the alternative; the research and development requirements and certainty levels of acceptance; and the implementation, operation, and maintenance problems inherent to each alternative.

CONCLUSIONS

1. The major problem in the use of pharmacy manpower is the peak loadings observed. Better scheduling procedures which allowed for in-patient drug dispensing during the slack periods would contribute to leveling the workload.
2. Both the unit drug and the automated outpatient drug distribution alternatives can be cost justified for BLHC System facilities.

RECOMMENDATIONS

1. The study team recommends that the unit drug alternative, together with the IV Additive and Auxiliary Clinical Pharmacist Alternatives be implemented for both inpatient and outpatient operations for all new BLHC facilities with more than 200 beds.

TABLE 3.3-43

IMPROVEMENT ALTERNATIVE	AVAILABILITY & R & D REQUESTED	CHANGES NEEDED IN DOD GUIDELINES?	CERTAINTY LEVELS OPTIONS	IMPLEMENTATION	PROBLEMS OPERATION	MAINTENANCE
Ward Component--	present	none -- normal procedure	MEDIUM predominate system today. Ward storage will probably continue even with new advances.	not applicable	Rising personnel costs, shortage of trained pers nnel, increasing service demands could force operational cutbacks	not applicable
Unit Dose --	1972 less than 18 months	Guidelines general enough to incorporate most changes	HIGH now used in ward stock & patient order sys. will be universally accepted for institutional use within 10 years.	Reorientation sessions for all medical and paramedical personnel. Incorporation into nursing education, initial packaging and distribution equipment costs high. Improved communications systems required.	Problems in training, management, raised by increase in technical personnel. Increased packaging costs.	Costs slightly higher because of increased equipment.
Mechanical Dispensing Devices	1975 less than 18 months	none	LOW	High initial equipment costs. Consideration of start-up costs.	Increased packaging costs.	Increased costs.
Automated--	1980 more than 18 months	none	HIGH prerequisite: total hospital information system.	Includes initial equipment costs of II plus cost of interlacing Westinghouse hospital information system.	Increase in packaging computer costs.	Increased costs.

TABLE 3.3-43 (Continued)

IMPROVEMENT ALTERNATIVE	AVAILABILITY & R & D REQUESTED	CHANGES NEEDED IN DOD GUIDELINES	CERTAINTY LEVELS OPTIONS	IMPLEMENTATION	PROBLEMS OPERATION	MAINTENANCE
IV Additives Programs--	1972 less than 18 months	none	HIGH Increased control of IV solutions and additives becoming accepted. Degree of implementation and centralization can vary.	Initial costs for equipment and facilities for "clean air" environment.	Increase in personnel	not applicable
Clinical Pharmacy Concept--	1972 less than 18 months	none	HIGH Concept invading profession. Total application would involve every administration and clinical level of medication system.	Reorientation sessions for medical and paramedical personnel. In service education important for pharmacy staff.	Professional salaries will rise as educational requirements increase. Increased personnel needs. (DoD - increase in rank)	not applicable
Drug Information Center--	1972 less than 18 months	none	MEDIUM Center refers not so much to physical location area as to staff commitment. Inter- and intra-institutional information dissemination of paramount importance.	Office space required in supportive services	Requires pharmacist with greater skills and training. Will increase computer costs.	not applicable
Automated Outpatient Dispensing--	1972 less than 18 months	None	HIGH Automated systems would increase efficiency and economy in outpatient dispensing by saving of professional personnel time.	Reorientation of pharmacy personnel. Trained terminal operators required. High initial costs for computer equipment and necessary programming	Increased computer costs	Increased computer maintenance costs

2. The feasibility of installing the total automated drug distribution alternative be carefully examined as it becomes available, since the automated alternative has a higher average rating for all evaluation criteria and a slightly higher life cycle cost savings than the recommended alternative. When it is entirely proven, it should be installed with minimal difficulty since it is compatible with unit dose.
3. Staff and design criteria be reexamined in light of the above recommendations.
4. The feasibility of facilities with less than 200 beds implementing a modified improvement alternative should be evaluated.
5. Introduce a drug information center for 750- to 1000- bed facilities.
6. Automatic (or automated) drug dispensing systems for the outpatient area should be installed in new BLHC Systems with outpatient prescription workloads in excess of 300/day.
7. DoD should study the feasibility of awarding service commissions to qualified pharmacists to function as pharmacists and not general MSC officers. The benefits of officer status would allow selective recruitment of pharmacists with graduate education or institutional experience; commissions would also enhance professional interaction among medical and paramedical personnel, increasing the probability of success for new concepts such as clinical pharmacy and drug information center.
8. DoD should study the implications of installing the recommended alternatives in all existing BLHC facilities over 200 beds.
9. DoD should develop a "prescription factor" similar to the techniques used for clinical laboratories (see page A-57).

EVALUATION ASSUMPTIONS

The pharmacy service evaluation is based on two assumptions. First, an average 7.2 doses per patient per day is normal in military and civilian hospitals (based on reports from six civilian hospitals in studies conducted by the Universities of Iowa and Kentucky).

Second, current personnel and equipment costs were assumed to be acceptable minimums and sufficient to attract professional personnel needed to implement and maintain the recommended level of service.

EVALUATION CRITERIA

All improvement alternatives have been evaluated in terms of quantified economic benefits and several subjective quality factors, such as safety, drug control, availability, efficiency, communications, and changes needed in DoD guidelines.

The four basic drug distribution alternatives were analyzed using the present ward stock alternative as a base; the remaining three alternatives were compared with the best alternative, based on cost. Final recommendations were based on results of the cost/benefit analysis plus qualitative factors relating, for example, to the system complexity and operating personnel requirements, etc.

The remaining six alternatives studies are recommended or rejected largely on the basis of subjective analysis.

The cost/benefit comparisons were based on present value life cycle costing. The cost of drugs were not included because the military's excellent purchasing procedures would not be changed significantly.

The evaluation assumed a life span of twenty years, a discount rate of 10 percent, a labor inflation rate of 4 percent annually, and a supplies inflation rate of 5 percent.

All analyses carefully considered the recommended professional responsibilities of the pharmacy department in the New Generation of Military Hospital. These responsibilities will be to:

1. Review the physician's original order
2. Review and record the patient's entire medication therapy, checking for drug sensitivities, therapeutic incompatabilities, and adverse reactions.

3. Prepare and identify the ultimate dosage for administration by the nurse.
4. Reduce errors by assuring that all drugs are administered to the patient at the right dose, route, and time.
5. Provide pharmaceutical information to physicians, nurses and other paramedical personnel.
6. Select, procure and store pharmaceuticals.

COST BENEFIT ANALYSIS

Present value life cycle costs were calculated for the four primary alternatives for several sizes of hospitals. The results are plotted on Figure 3.3-58. For all sizes of hospitals above 200 beds, automated drug distribution with unit dose has the best total present value costs, over the unit does system alone. Since the automated drug distribution alternative is not yet available, further analysis was confined to the unit dose alternative. The savings between the present methods and unit dose at the three BLHC Systems calculated over a 20 year period is summarized in Table 3.3-44.

TABLE 3.3-44 - PRESENT VALUE COST SAVINGS FOR UNIT DOSE AT THE THREE PRIMARY BLHCS

Hospital	Beaufort	Andrews	Walson
Ward Component (Present Method)	$1,276,800	$4,247,244	$5,407,137
Unit Dose	1,156,609	2,408,667	3,219,952
Savings	$ 119,191	$ 838,577	$2,187,185

Present value life cycle costs for the various auxiliary alternatives were calculated by applying these alternatives to the unit dose system. The results are shown in Table 3.3-45.

Adding the IV additives plus clinical pharmacy improvement alternatives to unit dose drug distribution will increase 20-year cost by $175,075 at Beaufort, $310,613 at Andrews and $639,801 at Walson. Subjective benefits,

Fig. 3.3-58 Pharmacy Alternatives

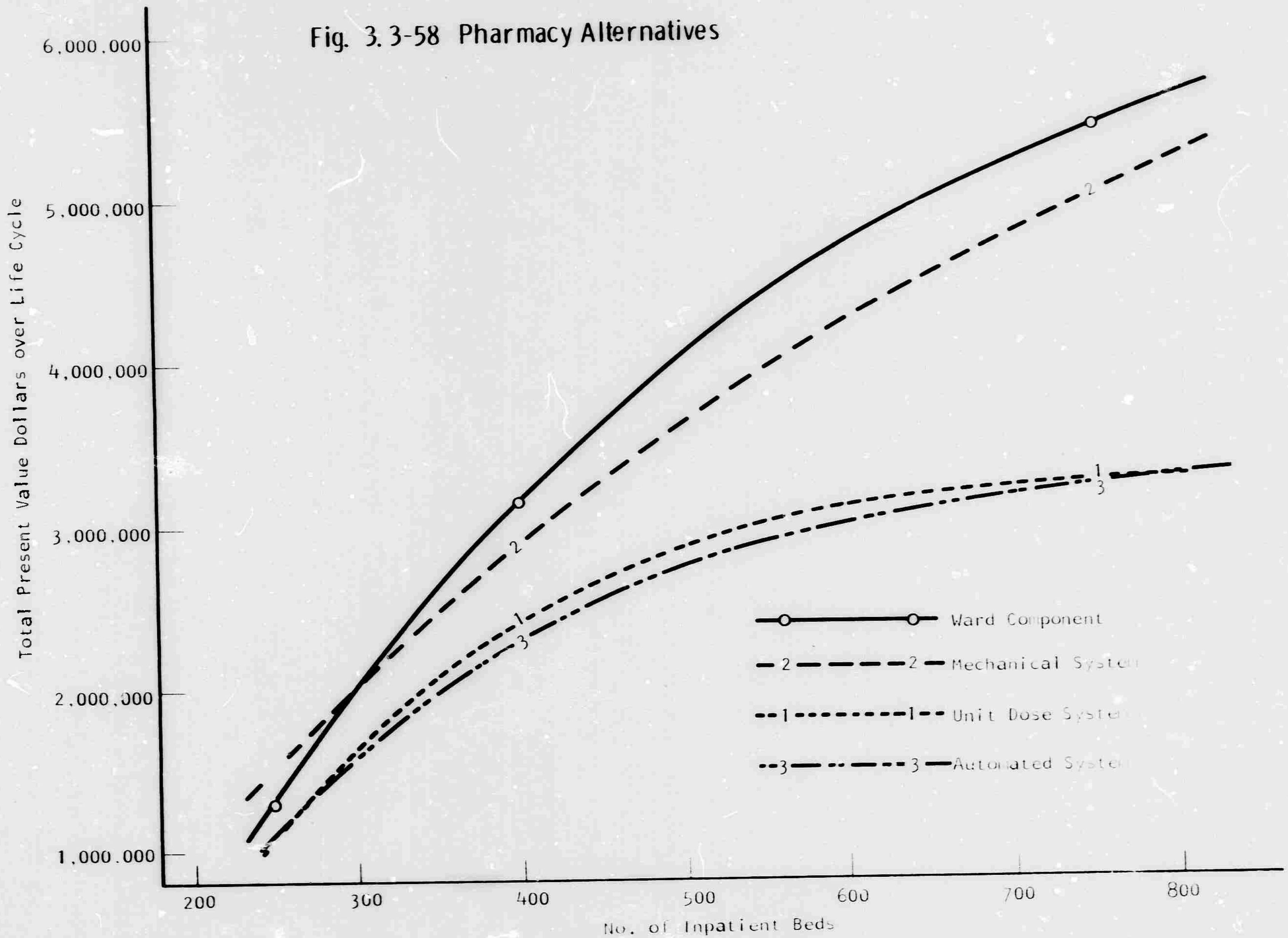


TABLE 3.3-45 PRESENT VALUE LIFE CYCLE COST FOR PHARMACY

Improvement Alternative	Pharmacy Personnel Cost/Year	Facility	Initial Equipment Cost	Yearly Supplies Cost	Medication Activity Personnel Cost/Year	1-5* Safety	1-5* Drug Control	1-5* Drug Availability	1-5* Communications	1-5* Drug Therapy	1-5* Efficiency	$ Savings Over 20-Year Life
Drug Distribution												
1. Ward Component												
Beaufort	$44,000	5.28sq.ft./bed	Not	$5,252	$174,195	1	1	3	2	2	2	Base (2)
Andrews	161,000	5.96sq.ft./bed	Determined	9,917	488,076							
Walson	192,000	2.92sq.ft./bed	(1)	23,338	693,729							
2. Unit Dose												
Beaufort	+29,000		$ +12,185	+1,748	-32,620	4	4	4	4	3	3	+120,000
Andrews	-14,000		+14,840	+3,306	-69,650							+838,000
Walson	-35,000	Slight Increase	+24,995	+7,778	-156,200							+2,287,000
3. Mechanical												
Beaufort	+12,000		+86,100	+148	+12,000	1	4	2	1	1	4	-25,000
Andrews	-40,000		+128,700	-817	-40,000							+392,000
Walson	-61,000	Negligible	+353,200	-1,738	-61,000							+385,392
4. Automated												
Beaufort	+7,000		+195,075	+8,748	-44,620	5	4	4	4	3	5	+210,000
Andrews	-66,000	Negligible	+282,075	+13,883	-113,650							+907,000
Walson	-83,000		+674,635	+21,862	-234,200							+2,296,000
5. Additives												
Beaufort	+8,500	30sq.ft./hosp.	+3,860	+550	+1,750	**Increased**	Signifi-	Same	Increased	Improved	In-	
Andrews	+17,000	50sq.ft./hosp.	+4,860	+750	+6,875		cantly				creased	
Walson	+34,000	70sq.ft./hosp.	+6,720	+1,050	+7,500		Increased					
6. Clinical Pharmacy												
Beaufort	+24,000	64sq.ft./unit	+1,265	No	+12,714	Increased	Signifi-	In-	In-	Signifi-	Same	-
Andrews	+36,000	64sq.ft./unit	+2,530	Effect	+18,855		cantly	creased	creased	cantly		
Walson	+96,000	64sq.ft./unit	+8,855		+50,640		Increased			Improved		
7. Drug Informantion Center												
Beaufort	+12,500	64sq.ft./hosp.	+1,150	+8,750	No	Increased	No	No	In-	Improved	No	-
Andrews	+25,000	80sq.ft./hosp.	+1,875	+10,600	Effect		Effect	Effect	creased		Effect	
Walson	+37,000	110so.ft./hosp.	+2,200	+12,450								
8. Pharmacy Prescribing												
Beaufort	+120,020	64sq.ft./unit(3)	+10,920(4)	No	+102,314	Sub-	In-	Signifi-	In-	Improved	No	
Andrews	+180,000	64sq.ft./unit	+16,380	Effect	+153,255	stantially	creased	cantly	creased		Effect	-
Walson	+396,000	64sq.ft./unit	+45,045		+324,240	Better		Increased				
9. Pharmacy Medication												
Beaufort	+36,000	No	No	No	-7,020	Increased	In-	No	No	No	Increased	-
Andrews	+52,000	Effect	Effect	Effect	-9,000		creased	Effect	Effect	Effect		
Walson	+134,000				-19,080							
10. Automated Outpatient												
Beaufort	0		+5,800	No	No	Increased	Signifi-	No	No	Improved	In-	-5,800
Andrews	-12,080		+13,400	Effect	Effect		cantly	Effect	Effect		creased	108,980
Walson	-9,000	Negligible	+9,600				Increased					+72,723

(1) The assumption is made that each base facility has the necessary equipment for the basic functions of dispensing, extemporaneous manufacturing and bulk repackaging.
(2) Base costs for the twenty-year period are projected in the cost analysis section.

***Rating Scale: 1 = Low; 5 = High**

3.3-187

particularly the substantial reduction of medication errors, will make implementation additionally beneficial.

Personnel costs for the Automated Outpatient Department Dispensing System at the three BLHC Systems studied is presented in Table 3.3-46. The additional annual equipment required for the three primary Systems is shown in Table 3.3-47.

TABLE 3.3-46 PERSONNEL COSTS FOR THE AUTOMATED OPD DISPENSING SYSTEMS

Hospital	Beaufort		Andrews		Walson	
	No.	Cost	No.	Cost	No.	Cost
Pharmacists @ $12,000/yr.	1	$12,000	3	$36,000	2	$24,000
Technicians @ $5,000/yr.	2	10,000	9	45,000	6	30,000
TOTAL		$22,000		$81,000		$54,000

TABLE 3.3-47 ADDITIONAL ANNUAL EQUIPMENT COST

Hospital Volume of Outpatient prescriptions per day	Beaufort 228		Andrews 1062		Walson 674	
	No.	Cost	No.	Cost	No.	Cost
Terminals	1	$1,800	3	$5,400	2	$3,600
CPU		4,000		8,000		6,000
TOTAL		$5,800		$13,400		$9,600

Present value life cycle cost savings (See Table 3.3-45) were calculated using a discount rate of 10 percent, a labor cost inflation rate of 4 percent supply inflation rate of 5 percent, and a zero equipment rental cost inflation rate. Personnel costs will be reduced at Andrews and Walson resulting in a 20-year savings of $108,980 and $72,723, respectively. At Beaufort, personnel costs will not be affected and the alternative cannot be recommended on a cost basis alone. We have estimated that a daily prescription volume of approximately 300 is required before this alternative can be cost-justified.

In evaluating the cost benefits of the four basic inpatient drug systems, changes in the discount rate and inflation rates used had no effect on the rankings. To determine the effect of changes in estimates of initial investment, labor, and supplies, Table 3.3-48 was developed from the present value cost benefit computer runoff:

TABLE 3.3-48
EFFECT OF CHANGE IN INITIAL INVESTMENT

Alternatives	% Individual Component would have to be increased, all other items remaining as is, to make P.V. Cost equal Ward Component		
	Initial Investment	Labor	Supplies
Unit Dose DDS	2199%	38%	437%
Medical DDS	253%	15%	322%
Automated DDS	294%	54%	242%

All systems are insensitive to errors in evaluating initial investment and supplies. Both the unit dose and the automated system are relatively insensitive to variations in labor cost estimates.

From a cost standpoint, the Automatic Outpatient Distribution System is insensitive to changes in Discount Rate but is very sensitive to changes in labor and rental cost inflation rates. Either decreasing the labor inflation rate to 0

percent or increasing the rental cost inflation rate to 4 percent makes this alternative economically infeasible. It then has to be evaluated on a subjective benefit analysis.

The automated alternative has a higher average rating for all evaluation criteria and a slightly higher life savings than the recommended unit dose. When it is entirely proven, it should be installed with minimal difficulty since it is compatible with unit dose.

RADIOLOGY

While the number of radiology films exposed has been increasing an average 12.8 percent over the past three years at the three hospitals studied (Beaufort 15.8 percent, Malcolm Grow 8.8 percent, and Walson 13.9 percent), the number of radiologists has increased only 3 percent per year. This widening gap between demand and qualified personnel has created a need to increase the productivity of the Radiologist and his staff, while maintaining quality and reducing cost per procedure and patient wait-time.

While Radiology represents only a relatively small percentage of the total operating costs of a BLHC System, the critical nature of its service, that is, the production of data essential to diagnosis and decision-making procedures which affect the total therapeutic process, makes it essential to improve the function wherever possible.

The basic procedures of the Radiology functions observed in the BLHC Systems are:

1. Patient registration
2. File search for previous patient records
3. X-ray examination
4. Film processing and development
5. Matching films to the patient's previous record
6. Transfer of films and records to the radiologist
7. Interpretation by the radiologist
8. Separate filing of the film package, the report, and record forms.

Westinghouse used work sampling techniques to evaluate personnel, facility utilization, and patient wait-time at the three BLHC Systems. The study findings are detailed in the data inventory volume; only the most significant problems of the present system are given below:

1. The poor scheduling interface between radiology and other BLHCS functions leads to the workload peaks shown in Figure 3.3-59. These activities also coincide with peaks in taking and developing films (Figure 3.3-60) and procedure room use (Figure 3.3-61). If this load could be leveled via better scheduling procedures, current resources and manpower could easily handle an increased workload.
2. Poor traffic patterns for both staff and patient flow contribute to inefficient patient handling throughout the X-ray cycle and to an inefficient film processing review cycle. These poor traffic patterns have two observable effects:
    a. Patient flow is unnecessarily slow.
    b. Staff time is used inefficiently in terms of number of procedures performed.
3. The present method of taking X-rays (which is unlikely to change significantly in the near future) results in extremely low machine utilization (see Table 3.3-49).

Consequently, to improve the productivity of the Radiology Department, while reducing costs, alternatives were examined primarily with respect to improving patient and staff flow patterns.

A breakdown of Radiology costs at the three BLHC Systems studied is shown in Table 3.3-50.

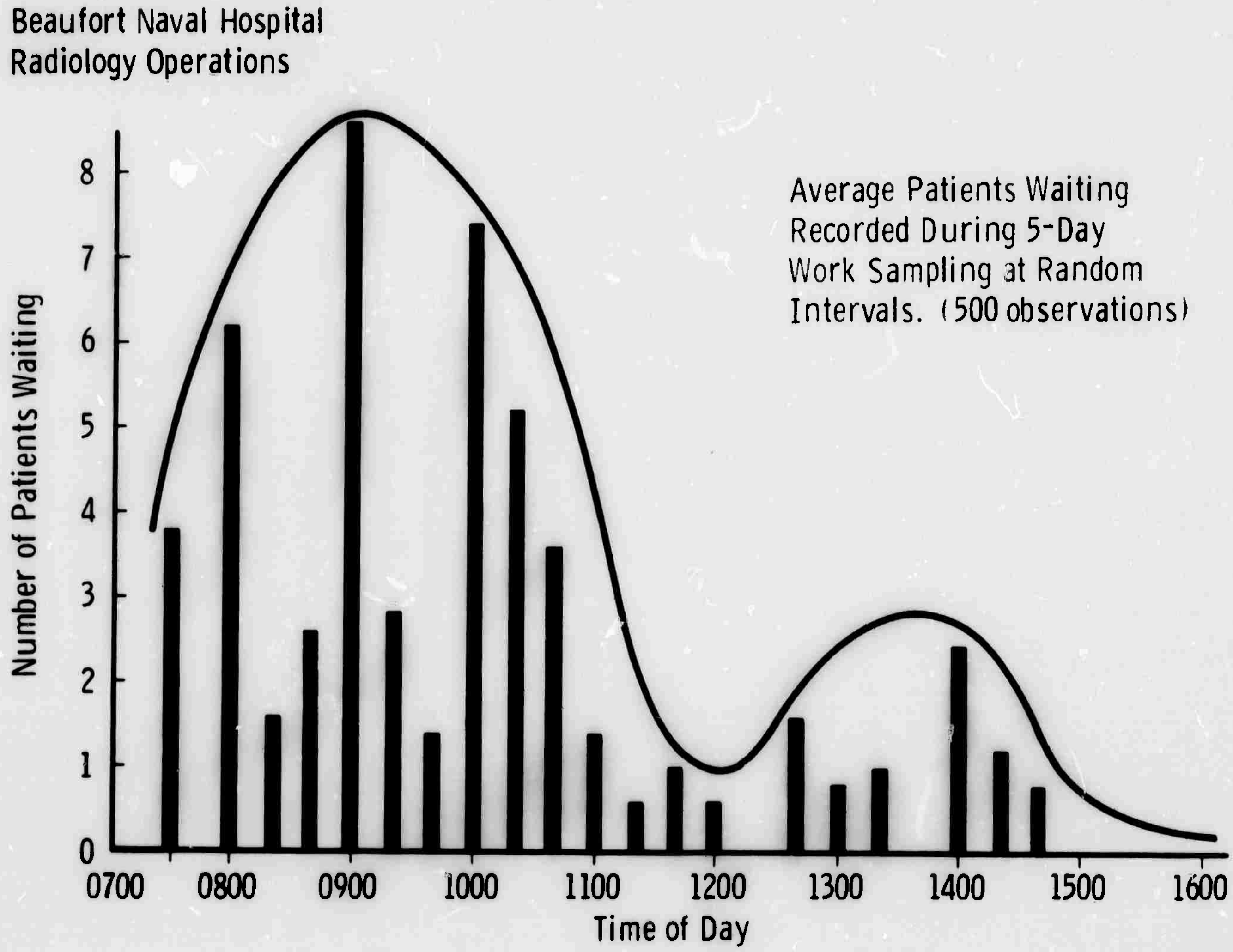


Fig. 3.3-59 —Profile of patients waiting

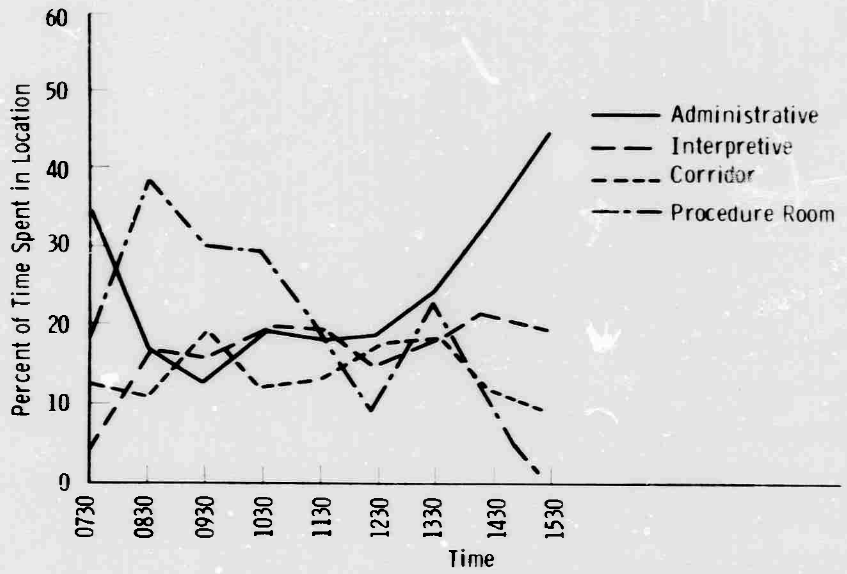


Fig. 3.3-61 —Radiology personnel location—Beaufort Naval Hosp

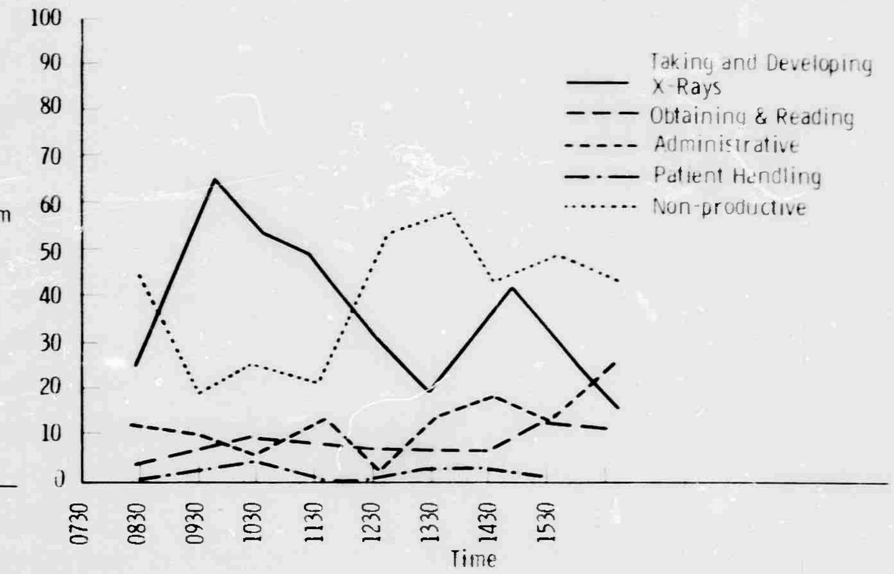


Fig. 3.3-60 —Radiology personnel utilization — Beaufort Naval Hosp

TABLE 3.3-49

RADIOLOGY - SUMMARY OF OBSERVED PROCEDURE TIMES AT

WALSOM ARMY HOSPITAL

Procedure	Average Time Patient in X-ray Room Min:Sec	Time for Dressing Min:Sec	Waiting Time for X-ray Min:Sec
IVP	28:23	7:20	
Renograph	29:50		
Knee	3:30	0:40	21:00
Ankle	5:04		29:05
Both Feet	3:03		42:30
Hand	3:56		25:49
Fingers	3:10		17:05
Nose	3:15		3:20
Sinus	4:45		3:25
Skull	6:35		14:50
Lumbar Spine	4:35	2:15	
Cervical Spine	2:50		5:25
Left Forearm	4:45		14:25
Chest	1:05	3:24	
Hips	3:25	1:00	12:05
Hip - Knee	6:00		
Pelvis	6:15	6:25	6:10
Shoulder	5:20		0:55
Flat and Upright Abdomen	4:20		14:00
Flat and Lateral Abdomen	8:45		8:30

TABLE 3.3-50*

RADIOLOGY COST BREAKDOWN

	Beaufort	Malcolm Grow	Walson
Personnel Cost/year	$43,326	$293,347	$257,662
Supplies, Maint., Housekeeping Training/year	31,338	151,054	143,887
Total Operating Cost/year	74,664	444,401	401,549
Cost per film exposed	1.98	2.45	1.34
Total Cost per procedure at 3.7 films/procedure	7.33	9.05	4.96
Personnel Cost/procedure	4.45	5.69	3.40
Number procedures/year	9,800	51,450	75,950

*Volume V - Data Inventory

Improvement Alternatives

Seven Improvement alternatives were evaluated:

1. Present Methods
2. Double Corridor Suite Layout. The Study Team feels this is particularly applicable to hospitals with less than 600 beds. It has two distinct traffic patterns: patients moving from the registration desk to the waiting room and to the examining room; and technicians and radiologists moving between film processing units and physician's reading rooms. Equipment layout and people flow patterns are shown in Figure 3.3-62.
3. Cluster Suite Layout (Figure 3.3-63) which the Study Team believes is best used in hospitals performing a high volume of special procedures. Each cluster features a central radiology reading station surrounded by rooms that can be used for specific examinations, such as fluoroscopy, intravenous pyelograms, or for emergencies or general purposes. The cluster suite layout divides the radiology department into semi-autonomous units which increase the efficiency of personnel and equipment. The cluster suite concept has not yet been implemented in any radiology department. Consequently, no hard facts were available, and only the theory could be investigated.

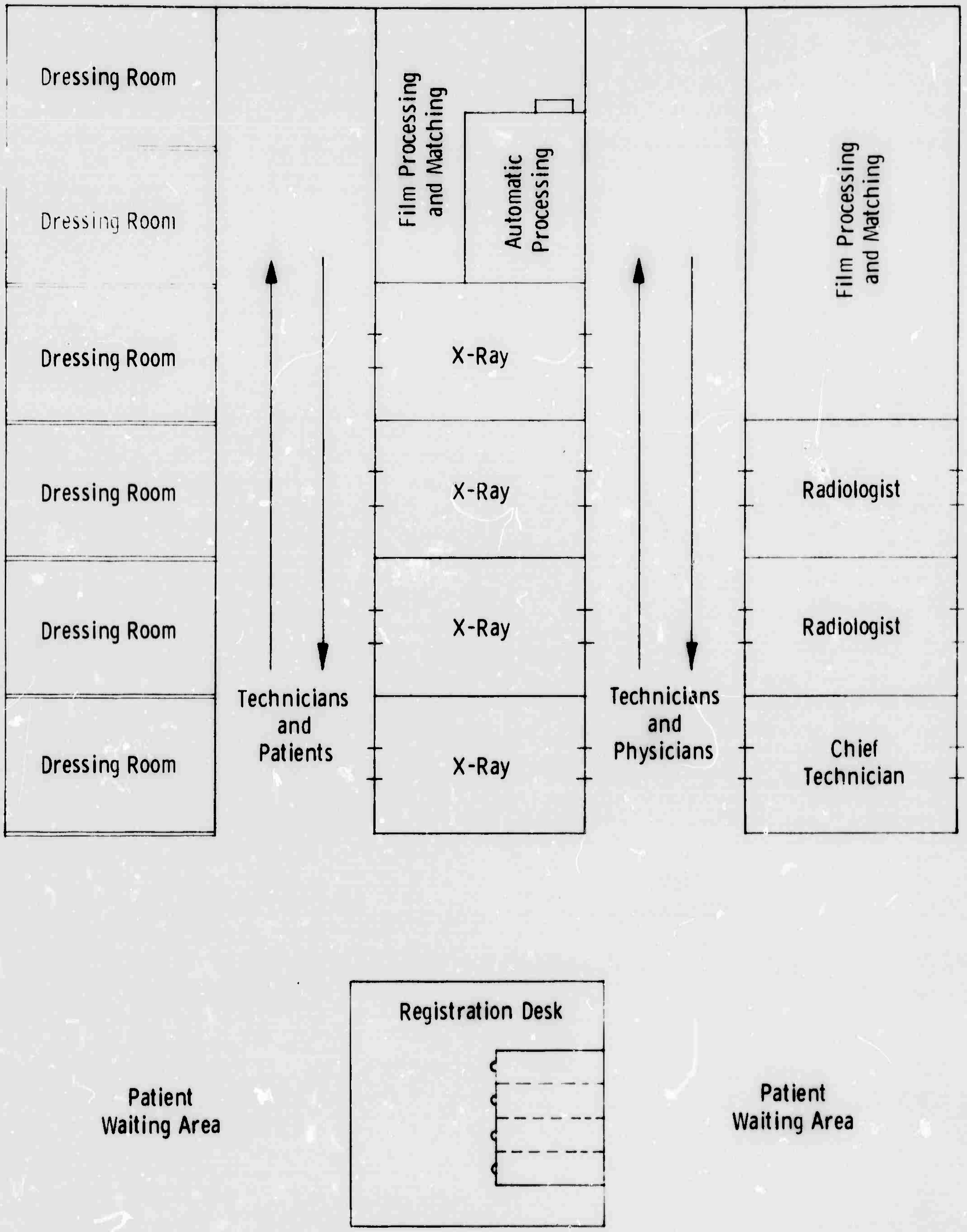


Fig. 3.3-62 – Double corridor layout

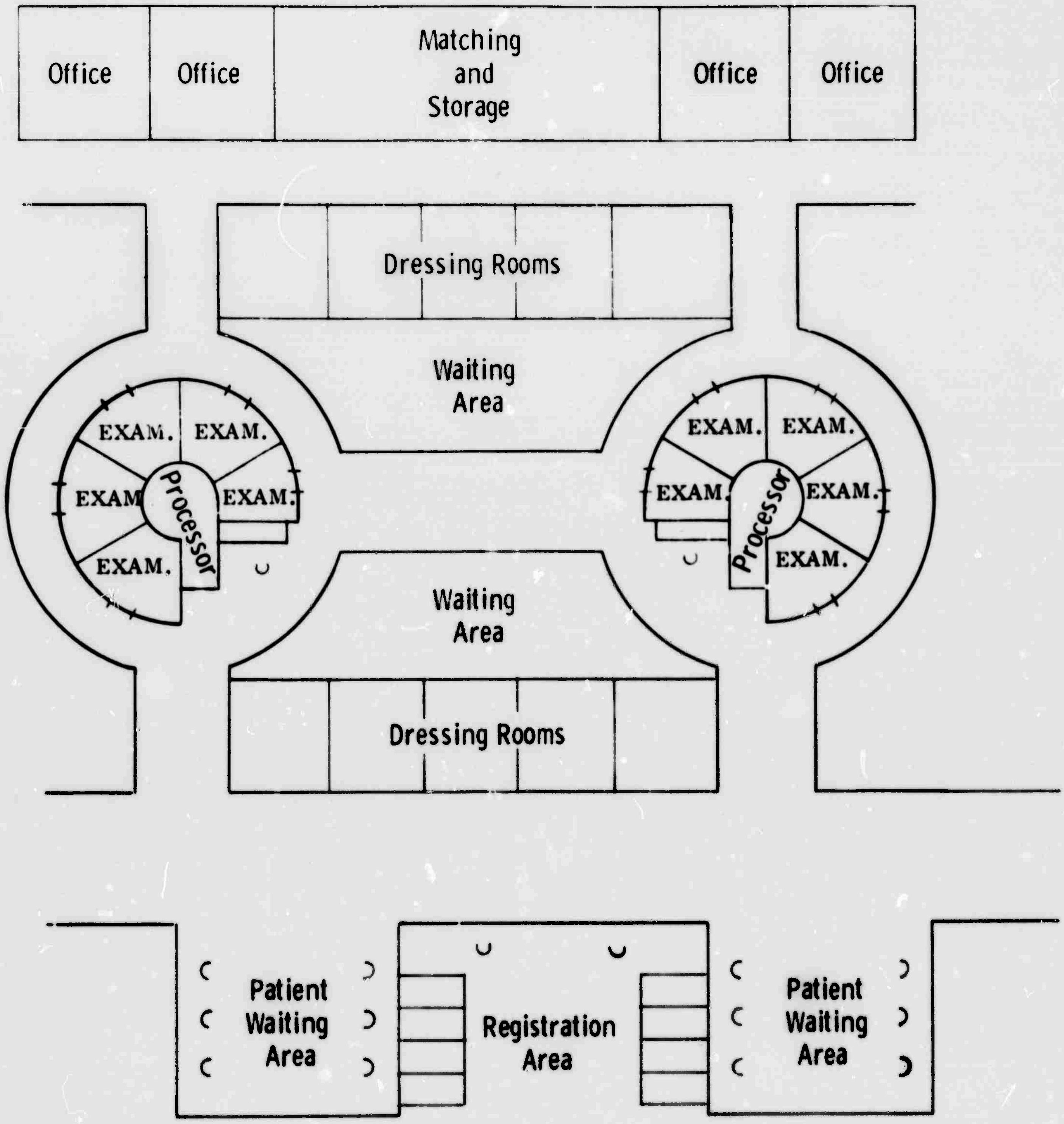


Fig. 3.3-63—Room cluster layout

4. Satellite stations, limited facilities located at a distance from the central radiology department, may be useful where population mobility is restricted. Satellites should be equipped with at least a single fixed table with 300 MA generator and overhead tube, an automatic processor, and one or two technicians. The facility should perform all bone (including skull) and chest examinations, as well as intravenous pyelography. It should have direct, continuous telephone communication with the central hospital, and films should be sent to the radiologist for interpretation daily or immediately in emergency cases. In non-emergencies, preliminary readings can be made by a general physician aided by an experienced technician at the satellite.
5. More automated radiology equipment. Many innovations in this area have been developed and are being marketed such as improved phototimers. Also available are 1) specialized equipment adapted to a single radiology procedure; 2) equipment with simplified controls to enable lower-skilled personnel to handle many procedures now performed by highly skilled technicians; 3) equipment designed to move and position the patient; 4) generators with higher milliamperage and spot films that record improved fluoroscopic images faster than conventional methods.
6. Use of more highly trained technicians would lessen the radiologist's workload; they are registered technicians specially trained to perform essential but routine procedures.
7. A centralized generator, used with an inexpensive high-voltage switch, to serve more than one X-ray unit, significantly reducing investment cost without decreasing quality or reliability. The concept is feasible because actual exposure time is a very small portion of the total time the X-ray equipment is being utilized.

In the conventional and double corridor alternatives (1 and 3, above) one generator can serve two rooms; in the cluster layout (alternative 4) four rooms can be served by one generator.

Conclusions

1. The major problem affecting workload peaks in Radiology is directly related to the manner in which patients are scheduled into X-ray from other parts of BLHC System., which can be improved through the use of an individual scheduling plan for radiology. All improvement alternatives considered in this report are directed to solving other problems.
2. The amount of time that the X-ray machine is actually in use is insignificant with respect to the total X-ray cycle. Consequently, only a very limited number of technological alternatives would have any major impact on cost and time savings.
3. Major improvement alternatives which would seem to have significant potential for the BLHC System are:
   a. Improved layouts to smooth the flow of patients from their entry to the Radiology department until they are properly positioned for X-ray procedures. Because of the importance of the Radiology Department in diagnostic processes and because of the increasing number of procedures dictated by changes in medical practice, any improvement alternative relating to facility layout or traffic patterns must necessarily be insensitive to changes in patient-mix and total load.
   b. Improved processing and quality control procedures to minimize time and manpower required to process film and evaluate quality prior to patient release and subsequent freeing of machine for the next patient.

c. Methods for relieving radiologist from routine and administrative chores so that his time can be used more productively in evaluating X-ray film and assisting in the diagnostic process.

Recommendations

1. The Radiology Department layout should be redesigned in the future to accommodate the double corridor concept for improved staff and patient traffic patterns.
2. Generators equipped to serve several X-ray machines should be used rather than the existing setup of one generator to one X-ray machine.
3. Further R&D evaluation should be made of the "Cluster Room" concept to determine its applicability to military hospitals.
4. Highly trained technicians should be increasingly employed as they are trained and become available.
5. For more effective use of both staff and facilities considerable study should be devoted to developing a rationale for more selective scheduling of both in- and outpatients to the Radiology Department.

Evaluation Assumptions

1. Department operates 260 days per year full time; remainder, part time.
2. There are 3.7 films per procedure.
3. Annual salaries plus fringe benefits are:
   a. Radiologist - $14,400
   b. Technician - 9,113
   c. Aide - 5,516
   d. Typist - 4,289
4. Except for central generators, equipment and supplies cost are similar for all comparable alternatives and, therefore, are not considered in any cost evaluations.

Evaluation Criteria

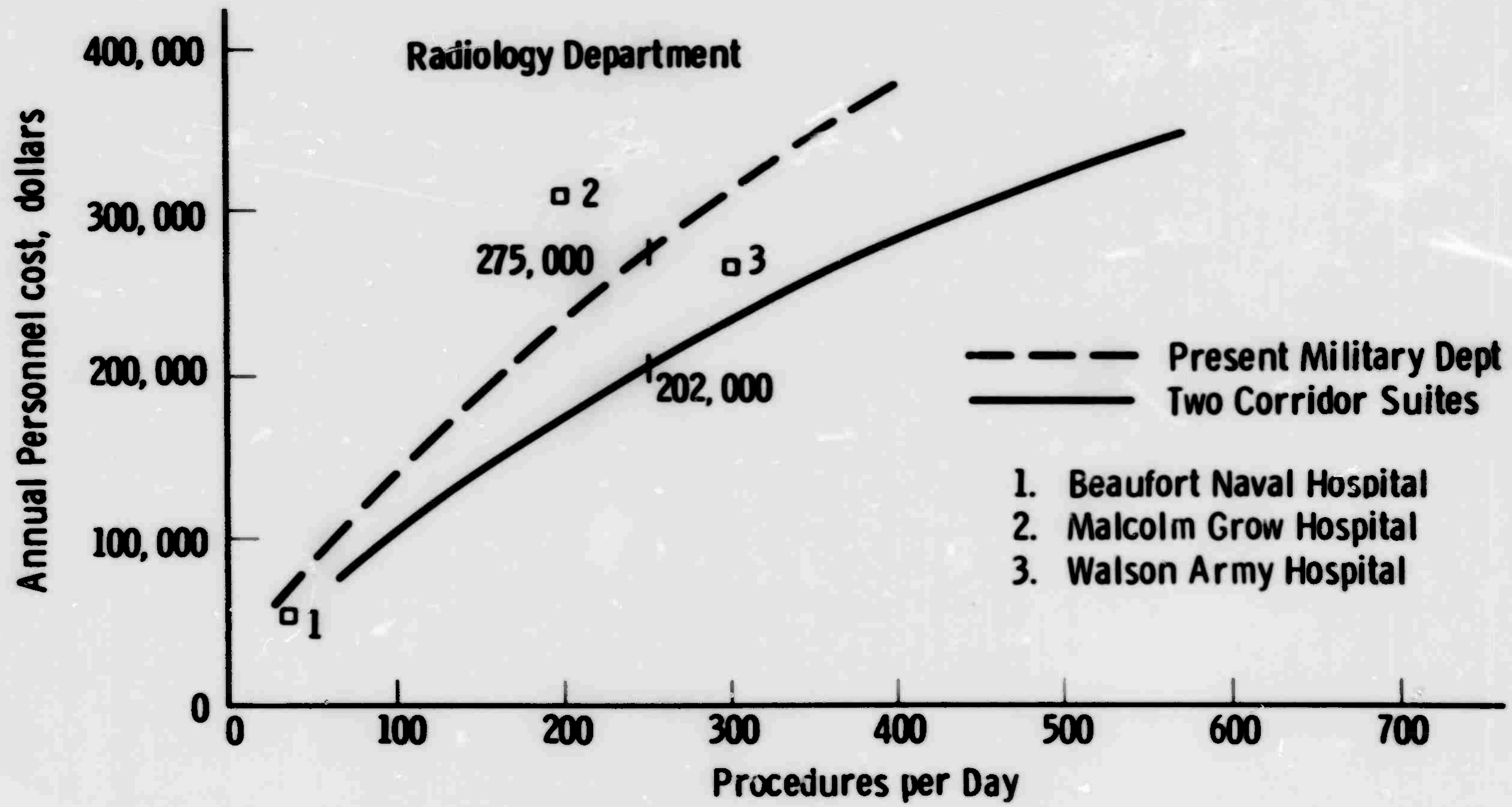
In addition to cost, the following qualitative criteria were used:

1. Flexibility - how well does the alternative adapt to changing patient mix and test demands.
2. Expandability - can the function's physical layout be easily expanded to meet increased demands.
3. Efficiency - how can the ratio of test/personnel/facilities be optimized.
4. Staff skill required - can the equipment be reliably operated by low-skill personnel.
5. Reliability - is the equipment mechanically and electronically reliable.
6. Staff utilization - are the technicians and Radiologists making the best use of their time.
7. Patient and Staff Flow - do people move throughout unit with a minimum of interference.
8. Quality - are examination results reproducible and adequate.

Cost/Benefit Analysis

The radiology function's layout affects personnel costs only; other costs per procedure are constant (with the exception of the centralized greater alternative) and, therefore, are not considered in the analysis.

Based on personnel needed for specific numbers of procedures per day and on data gathered on two-corridor staffing at Mt. Sinai hospital in Baltimore (Table 3.3-51), annual personnel costs for the present and double corridor alternatives were plotted against daily procedures (Figure 3.3-64). Comparable costs for the cluster alternative are not available.



Personnel Cost vs Examination per Day

TABLE 3.3-51

TWO CORRIDOR STAFFING

	PROCEDURE/DAY			
	100	200	300	500
Radiologists	1-2	2-4	5-7	6-10
Technicians	8-12	12-20	16-24	20-30
Aides	2-4	4-8	6-8	8-12
Typists	2	2-3	3-4	4-5

The ranges shown above reflect the difference in type of exams. For instance, a department doing 100/day may or may not perform vascular radiologic exams, which require extra personnel, including Radiologists and technicians.

The changing ratio of technicians, typists, and aides to procedures reflects their more efficient use of time with increased procedures.

If the double corridor layout is installed in a facility performing approximately 300 procedures per day, the Study Team estimates that annual personnel costs will be $78,000 below present practices and that the savings will increase as the number of procedures increase. Comparable cost savings will be realized despite variations in number of procedures because the two corridor cost curve is always better than the present single corridor layout.

Table 3.3-52 shows the initial cost savings that can be realized if centralized generators are installed; no operating savings will be realized with this alternative.

The facility referred to above would require four to six X-ray machines, depending on the mix of procedures. Using one generator instead of four would produce a saving potential of $59,000 in the first cost.

TABLE 3.3-52

COST SAVINGS - CENTRALIZED GENERATORS

No. Rooms	No. Generators	Cost of 750 ma 30 Generators	Switch Cost	Savings
4	4	$80,000	0	
4	2	$40,000	$1,500	$38,500
4	1	$20,000	750	$59,250

Table 3.3-53 displays a quantitative rating of each alternative's abilities to meet the evaluation criteria.

TABLE 3.3-53

	Procedures/day	Personnel Cost/year	Procedures/year	Personnel Cost/procedure	Flexibility	Expandability	Efficiency	Staff Skill Required	Reliability	Staff Utilization	Patient and Staff Flow
Present	100	$140,000	24,500	5.74	8*	5	5	5	-	6	5
	200	$232,000	49,000	4.75							
	300	$310,000	73,500	4.23							
Two Corridor	100	$102,000	24,500	4.16	8	9	8	5	-	7	8
	200	$175,000	49,000	3.58							
	300	$232,000	73,500	3.17							
Cluster	Not Available				8	8	9	4	-	8	7
Satellite	Not Available				6	9	4	6	-	4	5
Improved Equipment	Not Available				-	-	-	8	10	8	-
Master Technician	Not Available				-	-	-	-	-	9	-
Central Generator	Not Available				8	-	-	-	9	-	-

*Ratings are based on a 1 to 10 scale with 1 being lowest and 10 being highest.

3.4 Systems Application

INTRODUCTION

The improvement analysis section of the overall systems analysis has resulted in the development of several major improvements to the existing methodologies and techniques employed for predicting health care demands, generating the overall facility design, and determining the nature of staffing and equipping the facility for most effective and efficient care delivery. These methodologies and techniques are discussed in the Planning, Systems Design Concepts, and Operations Analysis sections, with overall conclusions for each stated in a generalized manner. Conclusions are qualified wherever they are modified by scale considerations, economic changes in the BLHC System or technological developments. Each section of the improvement analyses was based on a major need for improvement and resulted in the development of "Planning tools" which can be adopted by the military to produce better BLHC Systems without requiring major manpower additions or a fundamental reorganization of duties.

Westinghouse has adopted a strategy -- the use of a hypothetical Base "X" with initial and time varied population mix and military mission -- to demonstrate the application of these "tools" in one comprehensive example. This example shows the transition from the general to the particular as well as the interrelationship of each tool and its implications. The same methodology is applicable to any sized facility within the scope of the study. It begins with the needs of a beneficiary population over time and the implications of that population for defining and allocating required resources, considering the nature of the BLHCS level growth and changes.

Westinghouse has not developed three static solutions for system design as might be expected from a reading of the output requirements of the R.F.Q.: (hospitals characterized by: 250 inpatient beds associated with 300,000 outpatient visits/year; 500 inpatient beds associated with 450,000 outpatient visits/year; 750 inpatient beds associated with 650,000 outpatient visits/year). Rather, dynamic methodologies techniques has been developed which matches resources to

health care needs against changes over time, with very minor limitations in matching the facility and subsystems to these needs. No fixed relationship between inpatient and outpatient activity is locked into this methodology. The methodology is far more representative of the "real life" situation facing the military and thus far more valuable. Recognizing that some of the study outputs may not be judged suitable or immediately applicable, improvement alternatives are presented both in an interrelated form and separately.

In constructing Base "X", Westinghouse followed the same sequence of review and analysis required of the military planners and designers. The sequence is diagrammed in Figure 3.4-1.

It is applied to Base "X" as follows:

(1) The output of the Demand Model is used as the resource statement for design; however, a resource statement derived in the current manner could also serve as a design input and the text discusses the implications of changes which would then result.

(2) Changes to the resource statement used in design, caused by changes to current policy within the facility, are analyzed.

(3) The initial test design is generated by using current space and staffing criteria for each functional element of the system.

(4) The operational sub-systems are then applied to this test system; these sub-systems can be applied to almost any generalized design with the same capabilities.

(5) The impact of changes to the current planning criteria are immediately applicable and can thus be portrayed in an "improved" design.

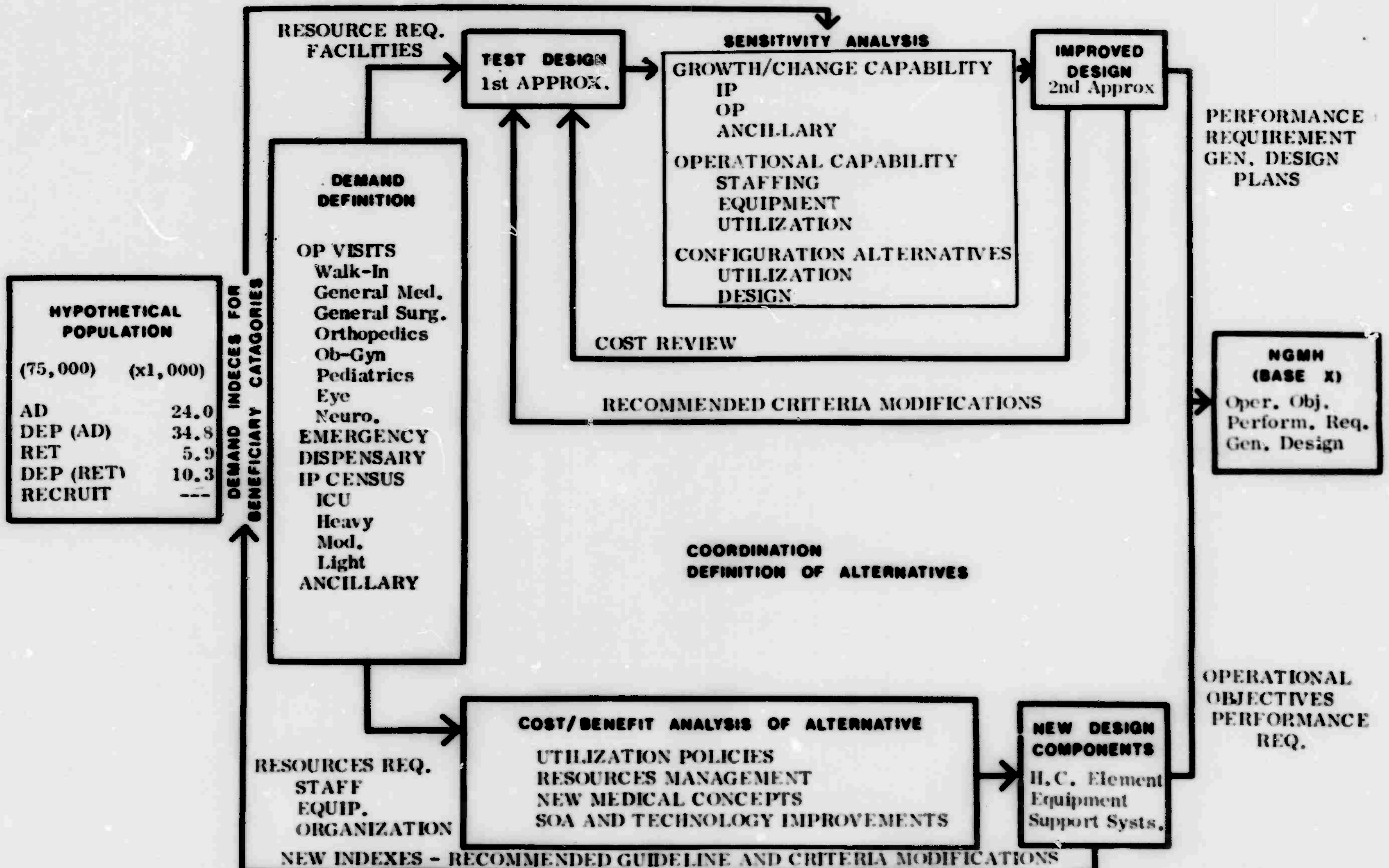
(6) The quantitative study conclusions are then summarized in a series of dynamic planning analyses which include such "real life" effects as budget limitations and delays.

DEFINITION OF BASE "X"

Base "X" was defined as having an initial beneficiary population of 75,000 comprising:

FIGURE 3.4-1 HYPOTHETICAL DESIGN MODEL FOR BASE "X"

TIME DYNAMICS T_0-T_{25}



Personnel	Number
Active Duty	24,600
Dependents (AD)	34,600
Retired	5,900
Dependents (RET)	10,000
Recruits	-

The population of 75,000 was chosen to fall in mid-range of the BLHC Systems as defined by the R.F.Q. This population is defined as normal for data observed in CONUS, in terms of distribution and age/sex characteristics of the BLHCS beneficiary categories. Retirees and their dependents are assumed to be growing in numbers and age/sex distribution, as defined by a DoD study. This growth can be stated as an average of 4.5 percent per year and is assumed to be constant and not related to changes in military mission.

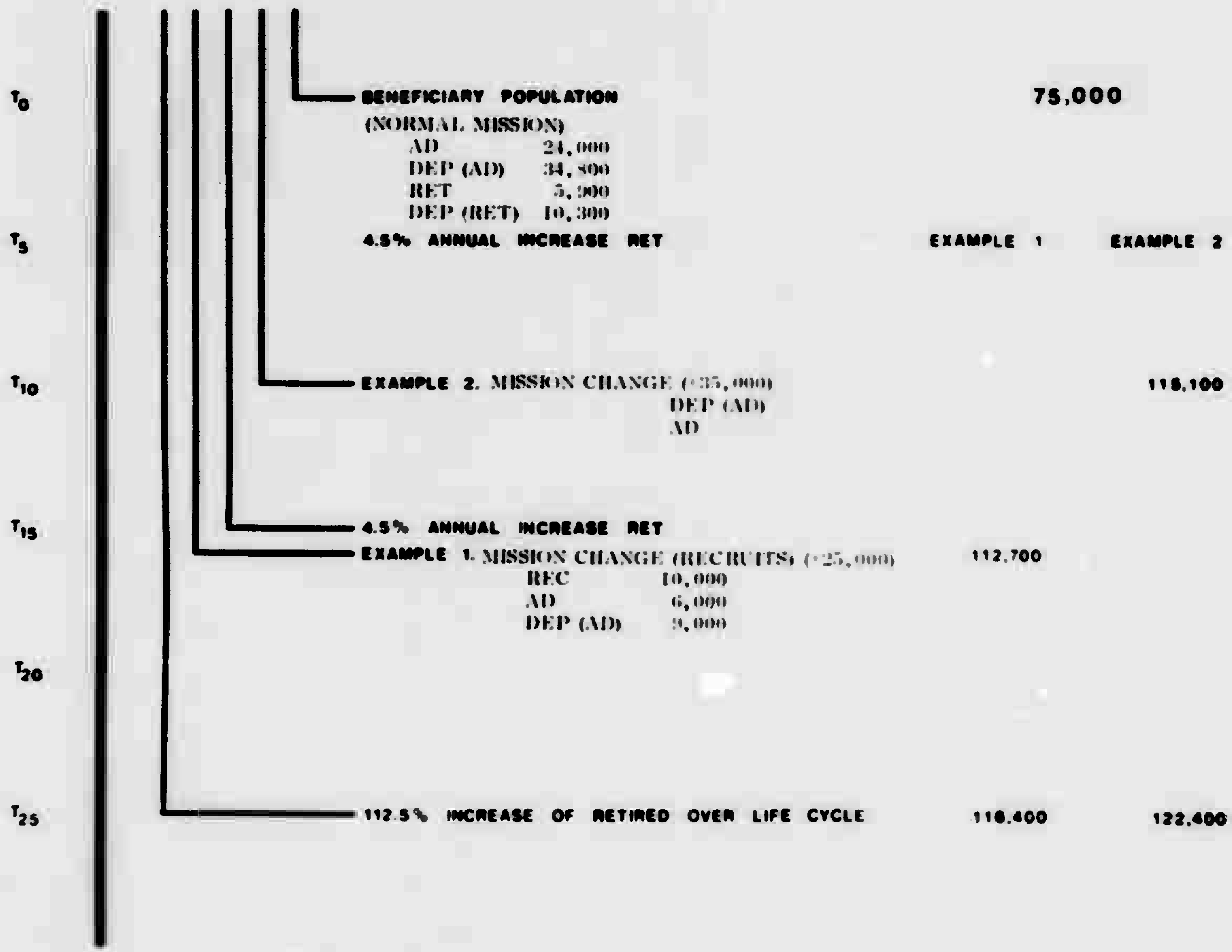
To illustrate dynamically what could reasonably occur in the military portion of the dependent population, the following subsets to the overall example were selected:

<u>Example 1</u> - Fifteen years after the base is operational, a mission change occurs which involves the addition of 10,000 recruits; 6,120 active duty military personnel, and 8,880 dependents related to these military personnel. No further major change occurs over the following ten years.

<u>Example 2</u> - Ten years after the base is operational, a mission change occurs which increases the active-duty military personnel by 10,300 and their dependents by 20,700. No further major change occurs over the following fifteen years.

These populations are illustrated in Figure 3.4-2. They were selected to illustrate typical base populations with characteristic variations in their health care needs. Westinghouse did not include civilians who are entitled to health care, or inter-base transfers for BLHC Systems which act as regional referral centers. Such refinement can be easily added by including demands of these other groups.

FIGURE 3.4-2 DEFINITION OF BASE "X" POPULATION



PLANNING

The beneficiary population statistics for both examples of Base "X" were aggregated at five year intervals over an assumed twenty-five year life and were used as inputs to the Demand Model. These data, together with the potential demand and utilization statistics for each population category are shown in the Tables 3.4-1 through 3.4-9.

(Note: Minor variations exist between the admissions rates shown in these tables and the final Demand Model data in the improvement analysis chapter which contains the latest data. These variations resulted from data refinement after Base "X" planning data was frozen to meet the contract deadline. They do not alter the demonstration value).

These Demand Model outputs reflect the resource requirements which the designers must provide for facility and operational capability, initially and over time, if all the potential medical and ancillary demand is to be met at Base "X". The resource requirements for system elements, other than medical and ancillary services, have not yet been generated as direct outputs of the Demand Model. The Westinghouse team was able to perform this task by using the current planning criteria and correlated their results with space programs for facilities with similar demands.

SYSTEMS DESIGN

The Westinghouse Team then performed the following process:

(1) The Demand Model outputs, the operational interrelationship embodied in the Design Model, current DoD criteria, and the most likely operations sub-systems alternatives were all synthesized into the first approximation of a test design for Base "X" in concept form.

(2) Detailed construction and operational sub-systems analyses and cost studies were undertaken.

(3) Sensitivity to the changes and growth indicated by the Demand Model was analyzed. T_0 = initial capability; T_{10} or T_{15} = the major mission changes for each example; T_N = ultimate capability. Together they show the ability of the design to accommodate even greater future change.

(4) An expert cost consulting company was retained to review the economics of the proposed system.

(5) An outside consulting company was brought in to review the economics of the proposed system.

(6) Cost data was generated for the Dynamic Optimization Program and life cycle cost construction strategies were generated.
The results of this work follow.

TABLE 3.4-1

BASE "X" POPULATION

			Population For Example #1		
Time Years	Recruit Strength	Active Duty Strength	Dependents of Active Duty	Retired Population	Dependents of Retired
0	0	24,000	34,800	5900	10,300
5	0	24,000	34,800	6564	11,459
10	0	24,000	34,800	7892	13,777
15	10,000	30,120	43,680	9220	16,095
20	10,000	30,120	43,680	10,548	18,413
25	10,000	30,120	43,680	11,876	20,731

			Population For Example #2		
Time Years	Recruit Strength	Active Duty Strength	Dependents of Active Duty	Retired Population	Dependents of Retired
0	0	24,000	34,800	5900	10,300
5	0	24,000	34,800	6564	11,459
10	0	34,300	55,500	7892	13,777
15	0	34,300	55,500	9220	16,095
20	0	34,300	55,500	10,548	18,413
25	0	34,300	55,500	11,876	20,731

TABLE 3.4-2

DEMANDS FOR SERVICES

INPATIENT ADMISSIONS
(Per Thousand Population)

Recruits	Active Duty	Dep. Act. Duty	Retired	Dep. Ret.
200	140	144	144	144

OUTPATIENT VISITS
(Per Thousand Population)

Recruits	Active Duty	Dep. Act. Duty	Retired	Dep. Ret.
4140	4260	4260	4180	4370

BIRTHS
(Per Thousand Population)

Dependents of Active Duty	Dependents of Retired
47.2	9.0

SURGICAL OPERATIONS
(Per Thousand)

Inpatients	Outpatients
658	130

TABLE 3.4-3

BREAKDOWN OF INPATIENT AND OUTPATIENT DEMANDS

AVERAGE LENGTH OF STAY IN LEVEL OF CARE (DAYS)

Time=0 Years	Recruit	Act. Duty	Dep. A.D.	Retired	Dep. Ret.
Intensive	0.366	0.295	0.062	0.354	0.213
Heavy	1.470	0.884	0.742	5.830	1.380
Moderate	13.600	8.540	5.190	7.620	6.400
Light	21.200	19.700	0.185	3.900	0.081
Time=5 Years					
Intensive	0.384	0.310	0.065	0.372	0.255
Heavy	1.544	0.928	0.779	6.132	1.449
Moderate	13.600	8.540	5.190	7.620	6.400
Light	20.988	19.503	0.183	3.861	0.080
Time=10 Years					
Intensive	0.404	0.325	0.068	0.390	0.268
Heavy	1.621	0.975	0.818	6.439	1.521
Moderate	13.600	8.540	5.190	7.620	6.400
Light	20.778	19.308	0.181	3.822	0.079
Time=15 Years					
Intensive	0.424	0.341	0.072	0.410	0.281
Heavy	1.702	1.023	0.859	6.761	1.598
Moderate	13.600	8.540	5.190	7.620	6.400
Light	20.570	19.115	0.180	3.784	0.079
Time=20 Years					
Intensive	0.445	0.359	0.075	0.430	0.295
Heavy	1.787	1.075	0.902	7.099	1.677
Moderate	13.600	8.540	5.190	7.620	6.400
Light	20.365	18.924	0.178	3.746	0.078
Time=25 Years					
Intensive	0.467	0.377	0.079	0.452	0.310
Heavy	1.876	1.128	0.947	7.453	1.761
Moderate	13.600	8.540	5.190	7.620	6.400
Light	20.161	18.735	0.176	3.709	0.077

PERCENTAGE DISTRIBUTION OF VISITS TO SPECIALTY CLINICS

Clinic	Recruit	Act. Duty	Dep. A.D.	Retired	Dep. Ret.
Orthopedic	0.06	0.06	0.03	0.02	0.05
OB/GYN	0.00	0.008	0.14	0.00	0.06
Pediatrics	0.00	0.00	0.29	0.00	0.08
EENT	0.04	0.04	0.01	0.03	0.01
Neuro/Psych	0.10	0.10	0.02	0.05	0.02
Surgical	0.16	0.16	0.07	0.11	0.07
Medical	0.44	0.432	0.20	0.40	0.37
Emergency Room	0.20	0.20	0.23	0.39	0.34
Total	1.00	1.00	1.00	1.00	1.00

TABLE 3.4-4

INPATIENT LAB PROCEDURES PER ADMISSION

Procedure	Recruit	Act. Duty	Dep. A.D.	Retired	Dep. Ret.
Hematology	1.4	1.4	1.1	4.4	2.5
Urology	0.2	1.2	1.2	2.1	1.2
Miscellaneous	0.3	1.3	0.9	1.2	2.7

INPATIENT RADIOLOGY PROCEDURES PER ADMISSION

Procedure	Recruit	Act. Duty	Dep. A.D.	Retired	Dep. Ret.
Major	0.1	0.1	0.1	0.7	0.1
Minor	0.6	0.4	0.3	0.6	0.4
Flouroscopies	0.1	0.1	0.1	0.1	0.1

PHARMACY PRESCRIPTIONS PER UNIT WORKLOAD

Prescriptions Per Inpatient Admission	Prescriptions Per Outpatient Visit
8.0	0.9

ANCILLARY USAGE PER OUTPATIENT VISIT

Service	Quantity	Units
Lab	0.6	Tests
Radiology	0.13	Procedures*
Radiology	0.005	Flouroscopies*

*(An average of 10 films per flouroscopy is assumed; an average of 3.5 films per other radiographic procedure is assumed).

TABLE 3.4-5

DEMAND BY BENEFICIARY CATEGORY

Population 1

Inpatient Admissions Per Year

Year	Recruits	Act. Duty	Dep. A.D.	Retired	Dep. Ret.
0	0	3360	5011	556	1483
5	0	3360	5011	945	1650
10	0	3360	5011	1136	1984
15	2000	4217	6290	1328	2318
20	2000	4217	6290	1519	2651
25	2000	4217	6290	1710	2985

OUTPATIENT VISITS PER YEAR

Year	Recruits	Act. Duty	Dep. A.D.	Retired	Dep. Ret.
0	0	102,240	148,248	24,662	45,011
5	0	102,240	148,248	27,438	50,076
10	0	102,240	148,248	32,989	60,205
15	41,400	128,311	186,077	38,540	70,335
20	41,400	128,311	186,077	44,091	80,465
25	41,400	128,311	186,077	49,642	90,594

TABLE 3.4-6

DEMAND BY BENEFICIARY CATEGORY
Population 2
INPATIENT ADMISSIONS PER YEAR

Year	Recruits	Act. Duty	Dep. A.D.	Retired	Dep. Ret.
0	0	3360	5011	850	1483
5	0	3360	5011	945	1650
10	0	4802	7992	1136	1984
15	0	4802	7992	1328	2318
20	0	4802	7992	1519	2651
25	0	4802	7992	1710	2985

OUTPATIENT VISITS PER YEAR

Year	Recruits	Act. Duty	Dep. A.D.	Retired	Dep. Ret.
0	0	102,240	148,248	24,662	45,011
5	0	102,240	148,248	27,438	50,676
10	0	146,118	236,430	32,989	60,205
15	0	146,118	236,430	38,540	70,335
20	0	146,118	236,430	44,091	80,465
25	0	146,118	236,430	49,642	90,594

TABLE 3.4-7

INPATIENT DEMAND
Population 2

Time Years	Intensive Care Unit Beds	Heavy Care Beds	Moderate Care Beds	Light Care Beds	Total Beds	Outpatient Visits Annually
0	5	38	194	193	430	320,161
5	6	42	199	192	438	328,001
10	8	61	278	266	613	480,129
15	9	67	294	270	640	491,423
20	10	76	304	269	659	507,103
25	11	85	314	268	679	522,784

TABLE 3.4-8

INPATIENT DEMAND

Population 1

Time Years	Intensive Care Unit Beds	Heavy Care Beds	Moderate Care Beds	Light Care Beds	Total Beds	Outpatient Visits Annually
0	5	38	194	193	430	320,161
5	6	42	199	192	438	328,001
10	7	49	208	193	456	343,682
15	11	75	334	193	613	432,363
20	12	79	341	349	782	480,343
25	13	89	351	348	801	496,024

TABLE 3.4-9

PROBABILITY DISTRIBUTION APPLICATION

(Base "X", Example 1)

1. T_0 Distribution of Bed Requirements by Levels of Care.

INPUT AVERAGE CENSUS?
AVERAGE CENSUS IS 4.355

ICU

N	P
12	.999399
10	.994713
7	.924873
5	.72748
4	.559829
2	.190556
1	.687713E-01
0	.128425E-01

INPUT AVERAGE CENSUS? - HEAVY
AVERAGE CENSUS IS 33.941

N	P
53	.998699
48	.989624
42	.922911
38	.7876
33	.486906
29	.22872
25	.664325E-01
21	.100522E-01
18	.138807E-02

INPUT AVERAGE CENSUS?
AVERAGE CENSUS IS 194.774

MODERATE

N	P
238	.998609
227	.988411
216	.937311
205	.781033
194	.499314
184	.233388
174	.702825E-01
164	.125036E-01
154	.12126E-02

INPUT AVERAGE CENSUS? - LIGHT
AVERAGE CENSUS IS 221.242

N	P
267	.998548
255	.987323
243	.930107
232	.777531
220	.486799
209	.216839
199	.691924E-01
188	.011569
178	.13113E-02

INPUT AVERAGE CENSUS? - TOTAL
AVERAGE CENSUS IS 454.312

N	P
520	.998697
503	.988076
486	.932627
470	.777669
454	.508193
438	.230719
422	.658507E-01
407	.124307E-01
392	.137997E-02

570 NOMINAL BEDS AT 0.8 UTILIZATION
SUM OF PROBABILITY FUNCTIONS

INTENSIVE	12	(.999%)
HEAVY	53	(.998%)
MODERATE	216	(.937%)
LIGHT	232	(.777%)
TOTAL	513	(.988)
NOMINAL	570	

DIFFERENTIAL -60 BEDS at T_0.

TABLE 3.4-9 (Cont'd)

2. T_{15} Distribution of Bed Requirements by Levels of Care.

INPUT AVERAGE CENSUS?
AVERAGE CENSUS IS 9.976

INTENSIVE

N	P
21	.999317
18	.992978
15	.952084
12	.793823
9	.460935
7	.22239
5	.679993E-01
3	.105192E-01
2	.28244E-02

INPUT AVERAGE CENSUS?
AVERAGE CENSUS IS 307.603

MODERATE

N	P
362	.9987
348	.988367
334	.934099
320	.769847
307	.501985
294	.228415
281	.655427E-01
269	.127907E-01
257	.148201E-02

INPUT AVERAGE CENSUS?-HEAVY
AVERAGE CENSUS IS 67.912

N	P
94	.998588
87	.987878
80	.931949
73	.756102
67	.492153
61	.221983
55	.607419E-01
50	.012744
45	.15688E-02

INPUT AVERAGE CENSUS? -LIGHT
AVERAGE CENSUS IS 326.074

N	P
382	.998707
367	.987409
353	.933384
339	.773244
325	.492842
312	.227972
299	.683131E-01
286	.122995E-01
273	.124645E-02

INPUT AVERAGE CENSUS?-TOTAL
AVERAGE CENSUS IS 711.625

N	P
793	.998626
772	.987588
751	.931029
731	.773115
711	.501863
691	.226526
671	.647168E-01
652	.120773E-01
633	.133324E-02

890 NOMINAL BEDS AT 0.8 UTILIZATION
SUM OF PROBABILITY FUNCTIONS

INTENSIVE	21	(.999%)
HEAVY	94	(.998%)
MODERATE	334	(.935%)
LIGHT	339	(.773%)
TOTAL	788	
NOMINAL	790	

DIFFERENTIAL 100 BEDS at T_{15}

First Approximation Test Design

The facility requirements for Base "X" at T_0 are defined by the application of current criteria to the Demand Model outputs. For the test design, the specific transformation process from demand to resources was limited to the health care elements of the system including inpatient beds, outpatient clinics by specialties, surgery, delivery, radiology, clinical laboratories, and pharmacy. For support functions, such as administration, dietary, and patient services, the scope was set at approximately that of current design facilities with a comparable patient load. This was done to focus the design effort on the essential health care elements of the system and to test their sensitivity to varying demands created by the time and mission dynamics.

The primary sensitivity of Example 1, the recruit mission, is the requirement for more inpatient beds, and the appropriateness of satellite health care facilities to respond to the first echelon of care requirements of the recruit population. The dispensaries may be detached, related to the troop housing area or contiguous to the composite facility. Their location is tied into the organizational logic of the design concept.

The application of current planning criteria to the general design logic (examples) has resulted in a facility with the following characteristics:

Time	Level	Square Feet
T_0	Ambulatory Level	125,000
	Medical/Administration Level	95,000 (+10,000 square feet unfinished space)
	Service Level	105,000
	Inpatient Levels (570 beds at 0.8 utilization)	165,000
	TOTAL	490,000 (+10,000 square feet)

T_{10}	Ambulatory Level	190,000
	Medical/Professional	130,000
	Service Level	130,000
	Inpatient levels (Nominal 820 beds at 0.8 utilization)	230,000
	TOTAL	680,000

T_N	Ambulatory Level	220,000
	Medical/Professional	130,000
	Service Level	130,000
	Inpatient Levels (1100 nominal beds at 0.8 utilization)	320,000
	TOTAL	800,000

The scope for the T_0 and T_{10}/T_{15} configurations were determined in considerable detail for each functional element (e.g., surgery, radiology,) to ensure that all Demand Model outputs can be directly translated into building areas using current criteria. The functional elements not included in the Demand Model (e.g., dietary and central sterile supply) were all calculated indirectly from data derived from the Demand Model. Dietary, for example, was calculated by comparing total inpatient demand with levels of dependency, assuming that a certain percentage of light care patients did not have meals in beds, but did receive all their needs in the hospital. This approach allowed the Team to work up all the non-medical areas with sufficient accuracy for design purposes.

Each scaled functional element was then arrayed within the overall design logic framework, already described. This logic was applied for each successive time framework for each population example selected for Base "X" -- T_1 T_{10}/T_{15}. Micro studies of each major functional area were then developed. Their ability to respond to the time base dynamic of the system without reduced

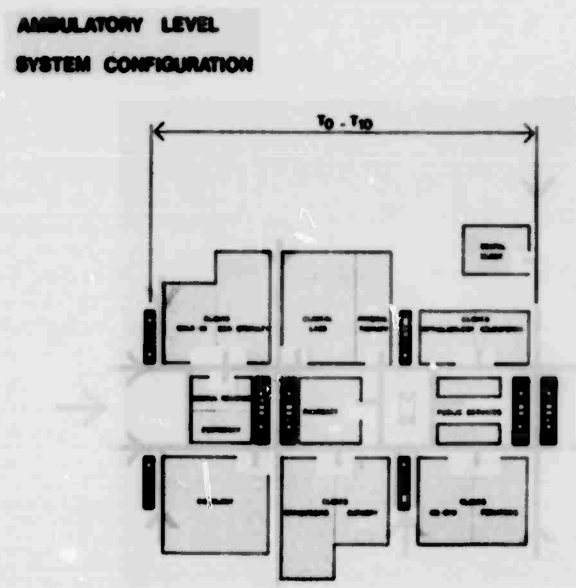


Figure 3.4-3 Ambulatory Level Patient Flow

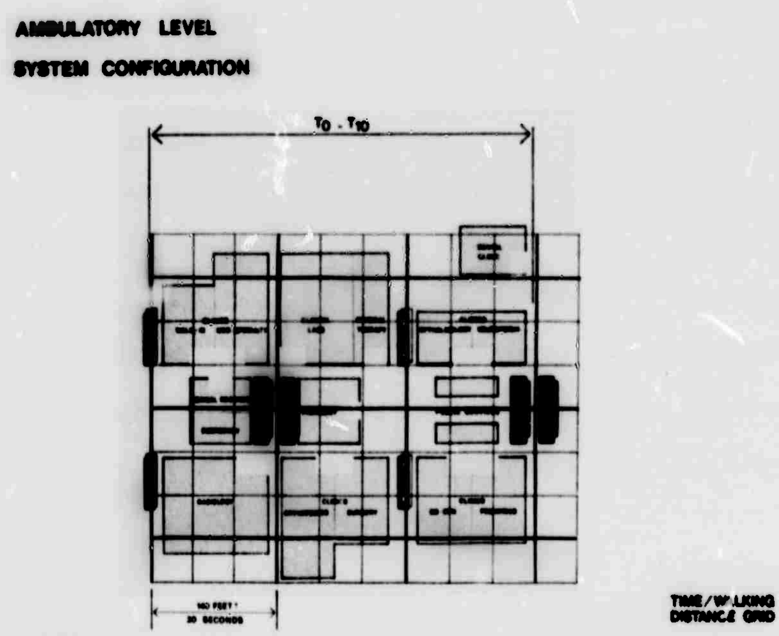


Figure 3.4-4 Ambulatory Level Time/Distance Grid

operational capability was tested where necessary, using computer-based adjacency studies as an aid to refining the overall design logic. Major operational and construction sub-systems were integrated into the design and evaluated.

The following is a summary of the functional and operating characteristics for each level of the Base "X" design configuration related to the time dynamics of demand, people, materiel, and communications flow which result from using the Design logic.

<u>Ambulatory Level</u> ($T_0 T_{10}$ and T_N)

The ambulatory treatment zone comprises most of the outpatient functional elements. Rapid, highly unpredictable change capabilities are generally demanded in forms that are small and difficult to define. Without disturbing or altering the organization of the patient entry and flow patterns, the design logic organizes the most flexible and selective planning concepts to allow multiple patient entry to the aggregate groupings of similar medical treatment areas. The waiting and flow characteristics of the ambulatory patients into, and between, these areas are organized, and an open-ended expansion of areas for highly unpredictable growth provided (Figure 3.4-3).

The time/distance grid was superimposed on the Base "X" layout to evaluate the total organization as well as specific subsets such as the emergency system relationship to its support services (Figure 3.4-4).

As illustrated in the improvement analysis section of this report, the major deficiencies in the outpatient area in current BLHC Systems include:

a) Ill-defined outpatient clinic areas
b) No room for expansion -- except by forcing growth patterns which destroy essential operational adjacencies
c) No capability for internal rearrangement or multiple usage by different specialties or personnel
d) Undesirable flow patterns both between clinics and between clinics and interrelated inpatient, ancillary, and support areas.

The Base "X" layout solves these problems within the design logic as follows:

- Well-defined zone for outpatient care. All outpatient care facilities, including the ancillary and support services, are located within the first level of the facilities. The clinics with high flow volumes are all at ground level, each with their own access point from the outside to reduce cross-traffic congestion.
- Open-ended expansion. Since the clinics with the most need for expansion are located along the perimeter of the first floor, they can be easily expanded, independently of one another. The T_{10} capability of the elements of the ambulatory level includes a system of growth which permits the open-ended expansion of some clinics within the time/distance relationship to the major modes and the limits of efficient internal layout. Other clinics can grow by displacement into adjacent areas of similar uses and by the construction of new clinic elements within an extended ambulatory level. (Figure 3.4-5).

  This system also provides the capability to upgrade the technology of the ambulatory zone as a function of time. The clinic which displaces another reverts to a lower echelon of care. (The medical specialty clinic becomes the walk-in clinic.) The newly constructed clinic can include the newest technology and concepts as they relate to that specialty service at the later time frame, thereby reducing the obsolescence rate of the overall BLHC System. The ultimate (T_N) capability of the ambulatory level indicates how a very large BLHCS may incorporate satellite health care elements, such as a dispensary or an outpatient surgery function, related to the overall organizational and functional framework of the composite facility.

The design model concept provides for locating the "dispensary function" (or neighborhood clinic) contiguously within the organizational logic of the composite facility. If dispersion is appropriate for a given BLHC System, the overall organizational logic is not affected. The linkages for the dispersed health care demand and facility elements to ancillary

CLINICS
GROWTH/CHANGE SYSTEM

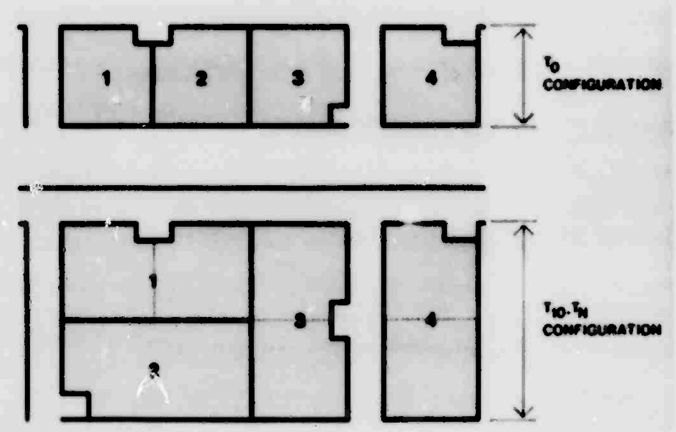


Figure 3.4-5 Growth/Change System for Clinics

MICRO STUDY
CLINIC WORKSTATION

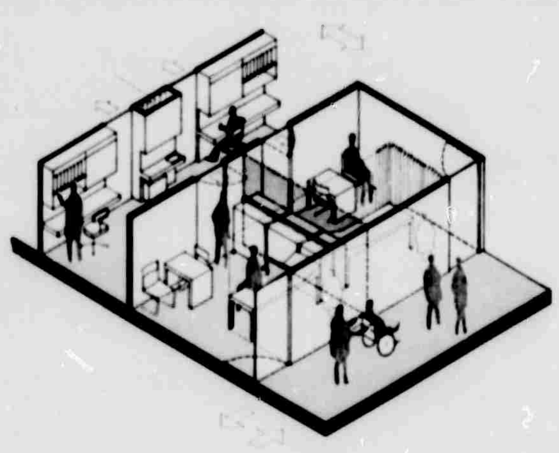


Figure 3.4-6 Combination Treatment and Examination Rooms

services (radiology, clinical laboratories, pharmacy, medical records) can be quantified and the appropriate ratios for resources between the composite and satellite facilities can be assigned.

- Capability for internal rearrangement and multiple usage. The grouping of similar clinics permits each to accept day-to-day operational fluctuations. The development of combination treatment and exam rooms permits multiple use by clinics (Figure 3.4-6) and by several physicians -- whose offices may be located in the medical-professional level related to the educational and training activities. This not only increases the throughput capability of the system but also permits the extra-hour shift operation suggested by the Medical Team. In the higher specialty clinics, where it is desirable for the physicians' offices to be in the clinic, criteria improvement for providing more examining rooms per physician will increase throughput and improve utilization of staff and facility. The clinic areas are largely free of fixed structural elements, because the inpatient towers are supported by the structural transfer zone. Because mechanical services are related to the entry and flow pattern and the service nodes, changes and modification are easily effected in the large column free modules (75 x 450) (Figure 3.4-7) and the predetermined mechanical service pattern (Figure 3.4-8).

- Flow patterns are used to determine adjacency. The provision of multiple entry points allows scheduled patients to park near the clinic and to enter that clinic directly. First visits are channeled to appropriate clinics along a spacious and well marked central corridor. The layout was refined by the use of a pairwise, computer-based optimization program (previously developed by Westinghouse for adjacency studies of manufacturing facilities) and the program and its application to Base "X" is described in Appendix 3.4-1. The computer assisted adjacency optimization program was considered as an elective refinement of the design concept and methodology.

AMBULATORY LEVEL

SYSTEM CONFIGURATION

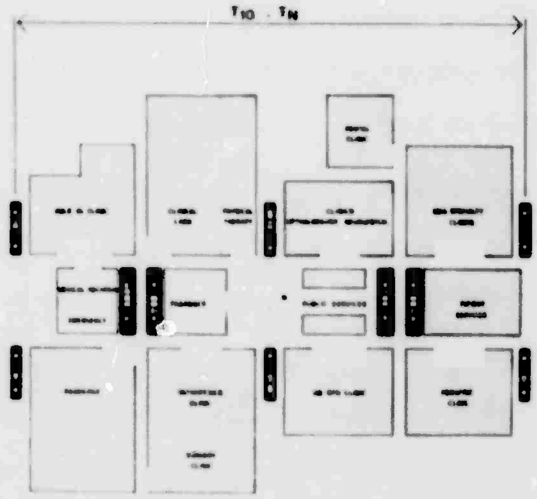


Figure 3.4-7 Ambulatory Level Showing Structural Overlay

AMBULATORY LEVEL

SYSTEM CONFIGURATION

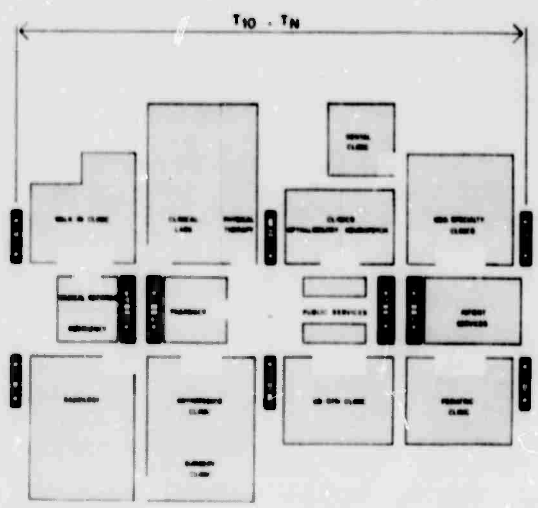


Figure 3.4-8 Ambulatory Level Mechanical Service Pattern

This design concept and methodology are not based on computers. The criteria for determining adjacencies is based on three critical items:

- staff flow
- communications (hand carried)
- patient flow

Each successive optimization was generated by weighting these items differently and adding in constraints related to issues, such as expansion capability.

Figure 3.4-9 reflects the final adjacency relationships based on the program results and, with minor modification, the layout of the ambulatory level of Base "X". The adjacency results reflect an overall reduction of flow and optimization of relationship which may leave any individual adjacencies in a sub-optimal relationship. Therefore, further micro-adjacency studies were undertaken to refine critical relationships such as that between the emergency department to its related services.

Figure 3.4-10 illustrates how this functional element is related to immediate critical adjacencies on a much smaller time/distance relationship, as well as how the vertical adjacency relationships relate to other functional elements such as surgery, intensive care, and the inpatient areas. These relationships have been refined to reflect the recommendations of the Medical Health Care Team and create the framework for evaluating specific hardware recommendations, such as the resuscitation elevator.

A similar analysis was used to refine adjacency relationships based on communication flows (See Figures 3.4-11, 12, & 13). The classification of communication relating to urgency of patient care required that these links be specifically considered. Further, the system of growth implied that at the T_{10} time frame some of the initial adjacency relationships are displaced and some of the links are extended as the organization framework expands.

Figures 3.4-14, 15, &16 also illustrate how the three highest volume communicators of the System, the most critical linkages, remain constant even though the System grows. The refinements based on staff flow criteria relate clinics by vertical adjacencies to the functional areas which are used by their physicians and staff. (Pediatric Clinic - Nursery; OB/Gyn Clinic - Surgery/ Delivery; Surgery/Orthopedic Clinic - Surgery/ICU). These relations are achieved

not only through discrete horizontal and vertical placement but also through relationships to the major and minor nodes which represent the links.

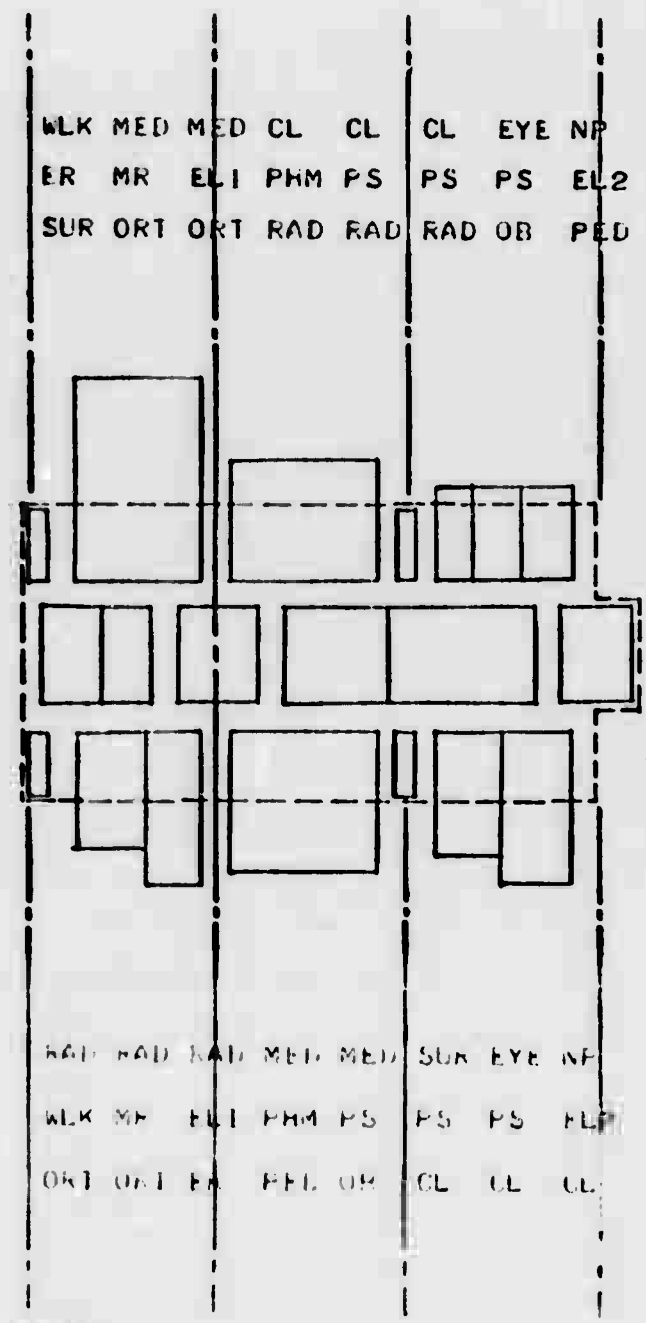
The final adjacency layouts represent refinements from computer results, refinements from medical review, and refinements from design based on the dynamic time change characteristics of the ambulatory level.

Figure 3.4-9. COMPUTER ADJACENCY STUDY

1. Idealized layout for computer input

2. Initial architectural plan showing layout correspondence

3. Final computer adjacency



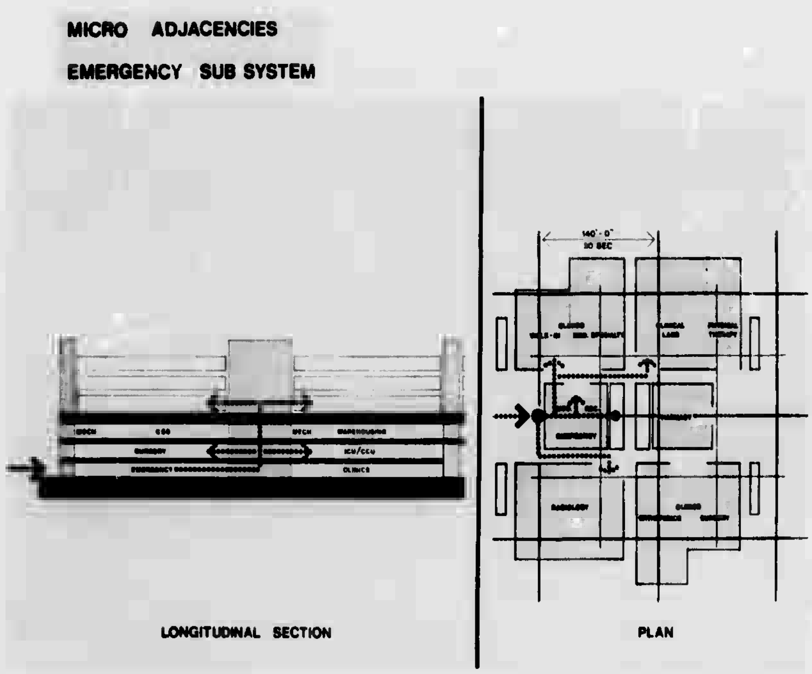


Figure 3.4-10 Micro Adjacencies
Emergency Sub-system

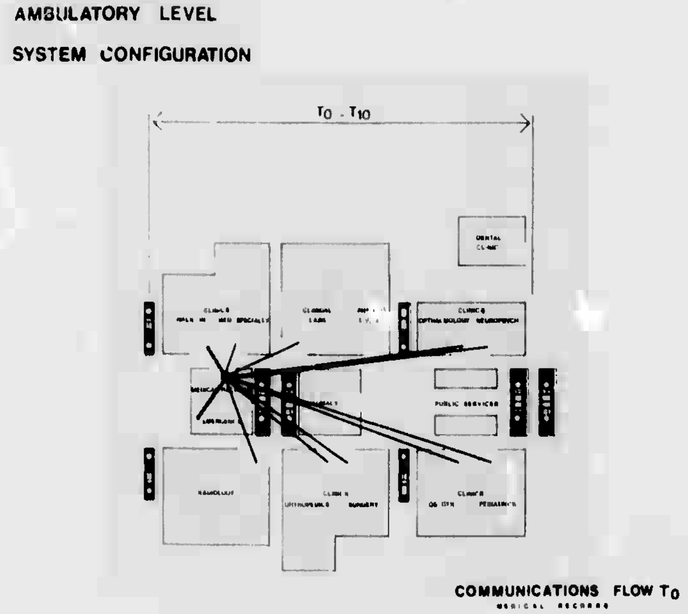


Figure 3.4-11 Ambulatory Level
Communications Flow to Medical Records (T_0 - T_{10})

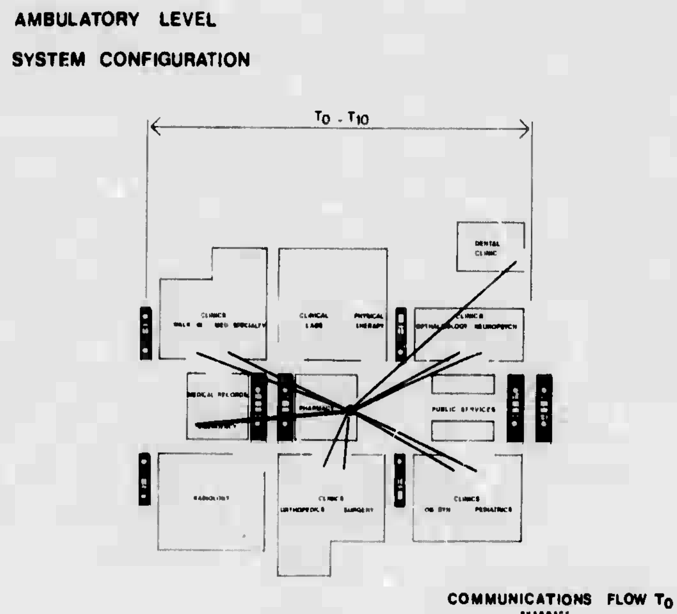


Figure 3.4-12 Ambulatory Level
Communications Flow to Pharmacy (T_0 - T_{10})

AMBULATORY LEVEL

SYSTEM CONFIGURATION

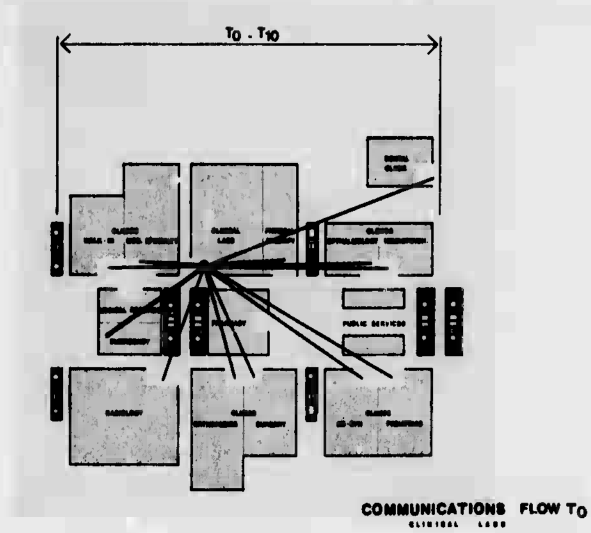


Figure 3.4-13 Ambulatory Level
Communications Flow to Clinical Laboratory (T_0 - T_{10})

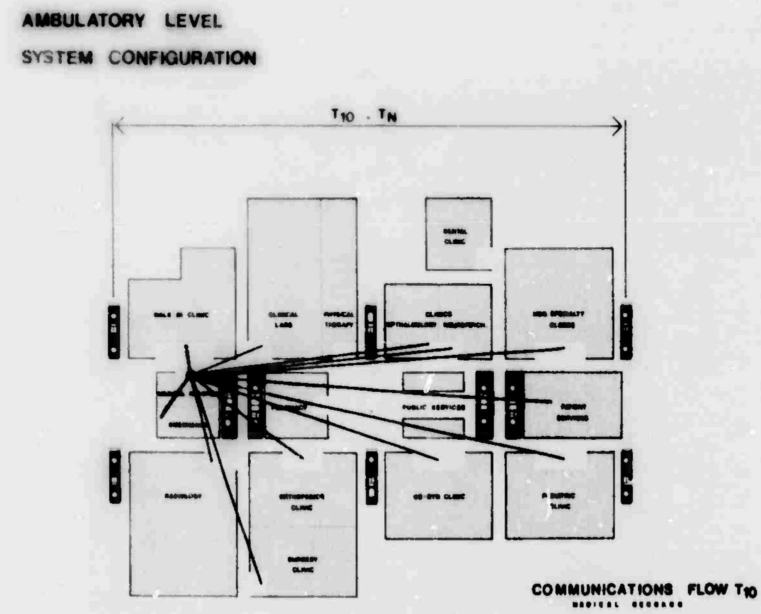


Figure 3.4-14 Ambulatory Level
Communications Flow to Medical Records (T_{10} - T_N)

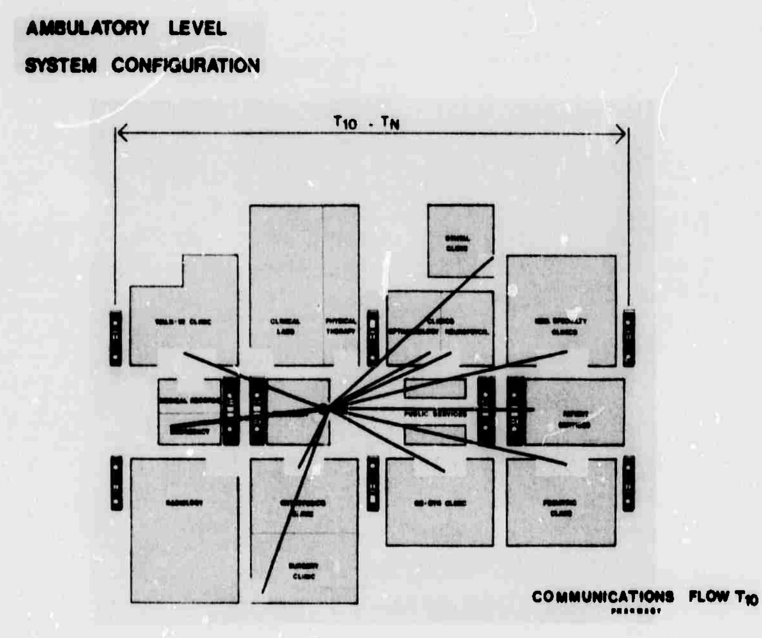


Figure 3.4-15 Amublatory Level
Communications Flow to Pharmacy (T_{10} - T_N)

AMBULATORY LEVEL

SYSTEM CONFIGURATION

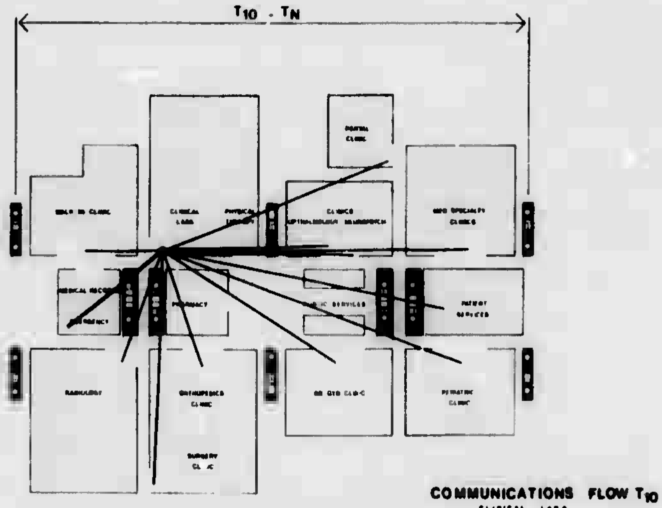


Figure 3.4-16 Ambulatory Level Communications Flow to Clinical Laboratory (T_{10} - T_N)

Medical/Professional Level

The functional elements of the medical and allied professional level are vertically related to the ambulatory level by the primary and secondary circulation nodes. Change flexibility of this level is enhanced by the accessibility of mechanical services contained within the large clear span modules (3 - 75' x 450'). (Figure 3.4-17.) Unfinished space is provided for the step function growth of the major health care elements (surgery and delivery). Surgery is considered a sub-system which includes the recovery and intensive care elements. Modules of growth are designed so that this area can grow from an initial 6-8 theaters at T_0 to a total of 12 theaters at T_N to match the demand. The diagram illustrates how the basic flow of patients, staff, and supplies is maintained during these changes without unduly extending the horizontal distances. The specific patient flow sequence from entry, to surgery, to recovery, and then intensive care reflects the progression and condition of the patient (Figure 3.4-18).

This design logic reduces the technological obsolescence of the BLHC System during its life cycle. The space modules are uniform and will accommodate all surgical procedures except organ transplants. (Figure 3.4-19.) At T_{10}/T_{15} when expansion is required, new procedures and new technology can be incorporated into the new elements within the surgical suite. A new concept relating to the operating suite may increase the size of the module and reduce the total number of suites possible in the planned growth. However, the design configuration illustrates the possibility of relating an outpatient surgery department to the ambulatory zone, thereby easing the demand on the suite and freeing it for more serious procedures. New health care elements and changed mission requirements such as teaching may require expanded capabilities (T_N) associated with larger BLHC Systems (700-1000 beds), and can be accommodated with a major increment of growth of the medical, administrative, and service levels.

MEDICAL-ADMINISTRATIVE LEVEL

SYSTEM CONFIGURATION

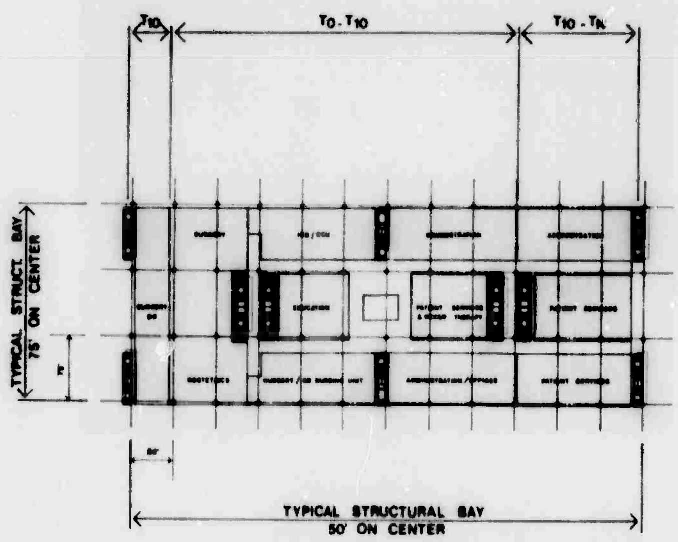


Figure 3.4-17 Medical-Administrative Level Structure Overlay

SURGERY

GROWTH SYSTEM

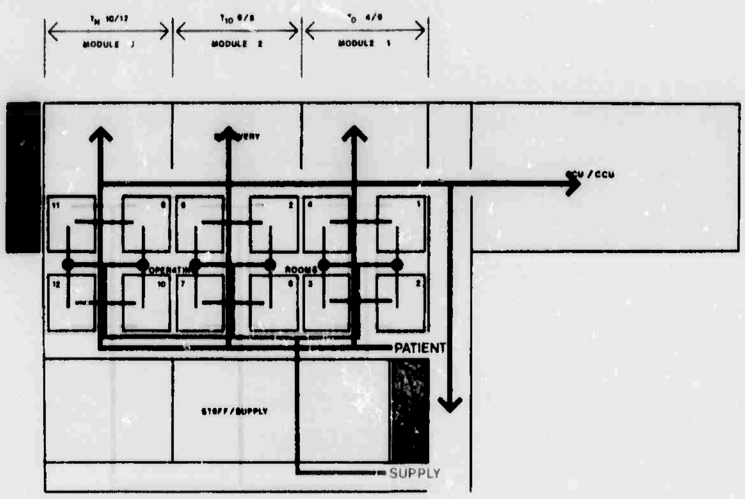


Figure 3.4-18 Staff, Patient and Materiel Flows for Surgery

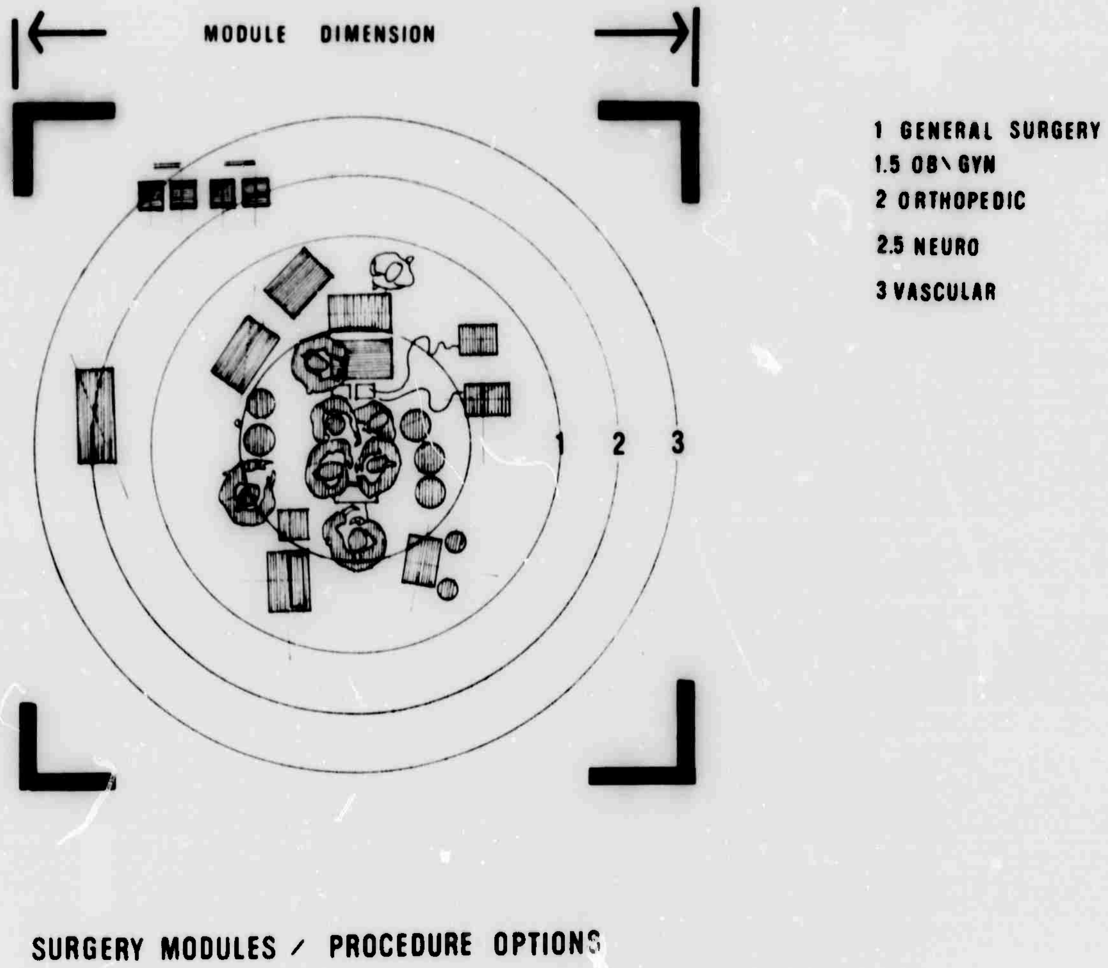


Figure 3.4-19 Surgery Space Module
Procedure Options

Service Level/Structural Transfer Zone (Figures 3.4-20 and 3.4-21)

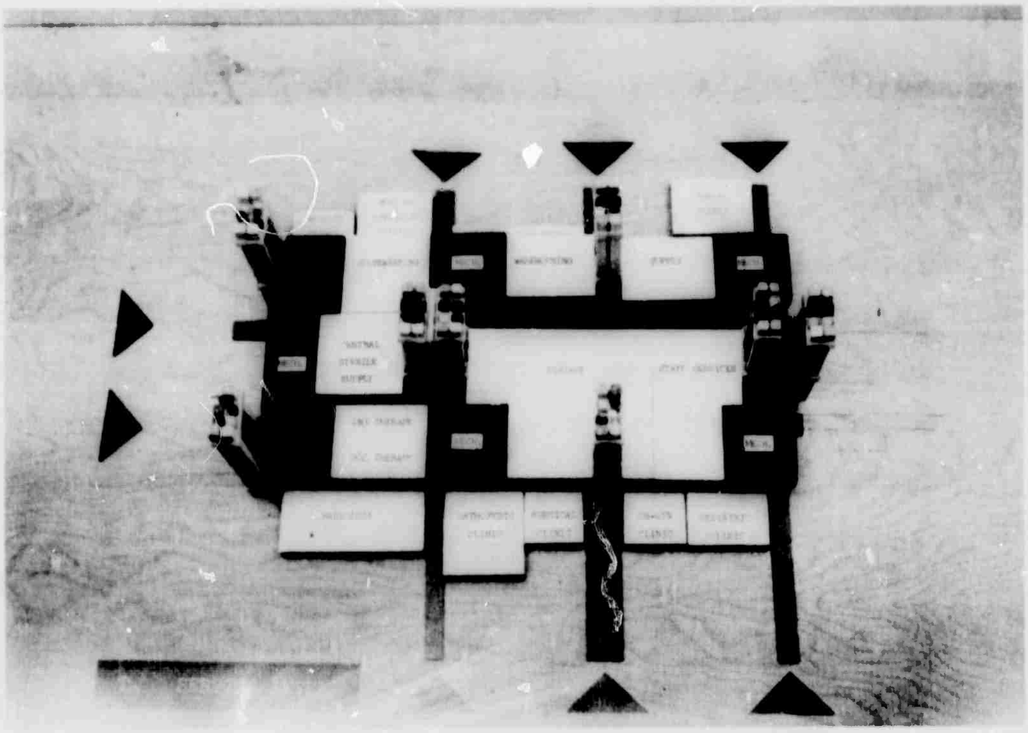
The Service Level is directly related to the structural transfer zone concept and is placed nearest to the elements dependent on service support -- inpatient levels and other functions with important vertical adjacency requirements, such as Central Sterile to Surgery and Delivery (Figure 3.4-22). The Bethlehem Steel and U. S. Steel Companies helped evaluate cost and flexibility implications for several structural sub-systems, both for this level and the overall facility structure. The implications of various structural alternatives on the design flexibility are illustrated in Figures 3.4-23 and 3.4-24.

The major design objective for the structural transfer zone is to free the lower floors of the constraints to change and growth normally encountered when the structural treatments of the inpatient areas are continued to grade. A two-way truss structural system was chosen for this level in order to provide the greatest flexibility (Figure 3.4-23). Although its initial cost is highest, some flexibility is lost if a less expensive structural system is substituted.

Similarly, design concepts have been developed for utilities such as plumbing, heating, ventilating, and air conditioning (HVAC), and electrical. Sub-systems allow discrete selection of components and major distribution and control systems to ensure the least life cycle costs in the context of the system's demands for change flexibility. The structural and other major construction sub-systems have not been integrated for the same reasons. Figure 3.4-25 illustrates the relationship of mechanical equipment rooms, all grouped on the service level, and the utilities distribution to the inpatient areas and lower levels. The inpatient areas utilize a peripheral system of distribution from mains running in the trusses of the service level. The remainder of the building is served from major risers in the primary and secondary nodes with major horizontal distribution following the circulation patterns at each floor.

FIGURE 3.4-20 SERVICE LEVEL

T_0



T_{10}/T_N

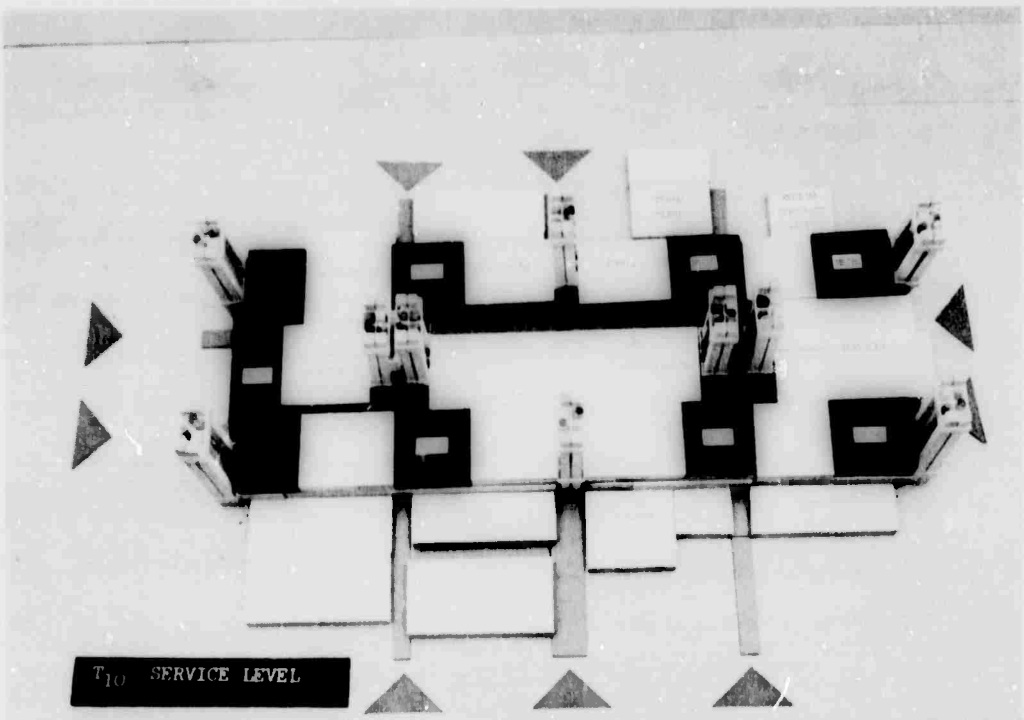
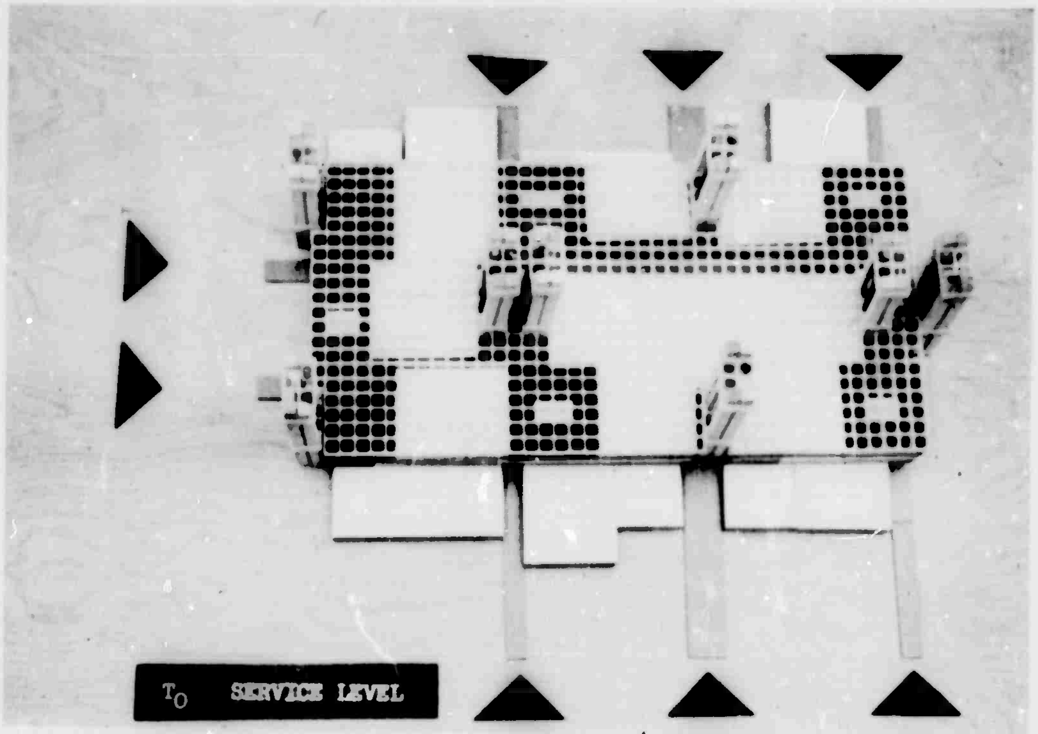
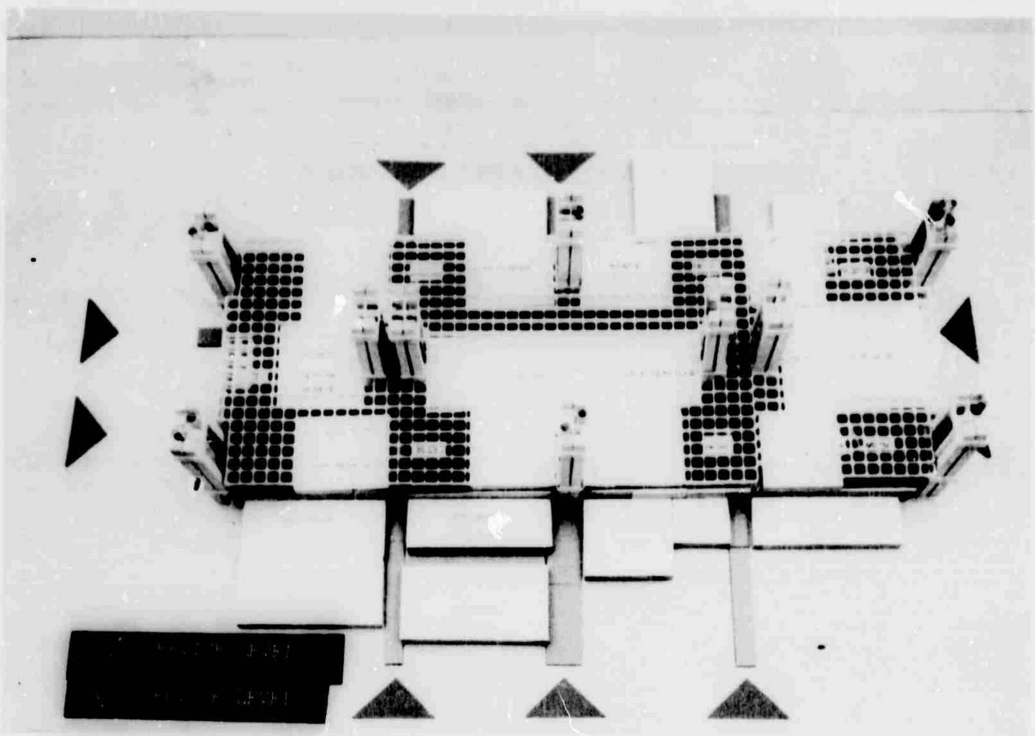


FIGURE 3.4-21 STRUCTURAL ZONE



T_0



T_{10}/T_N

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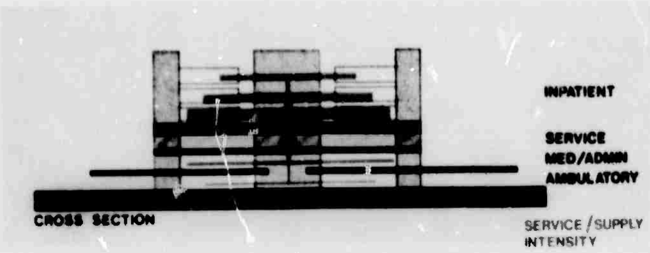


Figure 3.4-22 Service/Supply
for Inpatient Levels

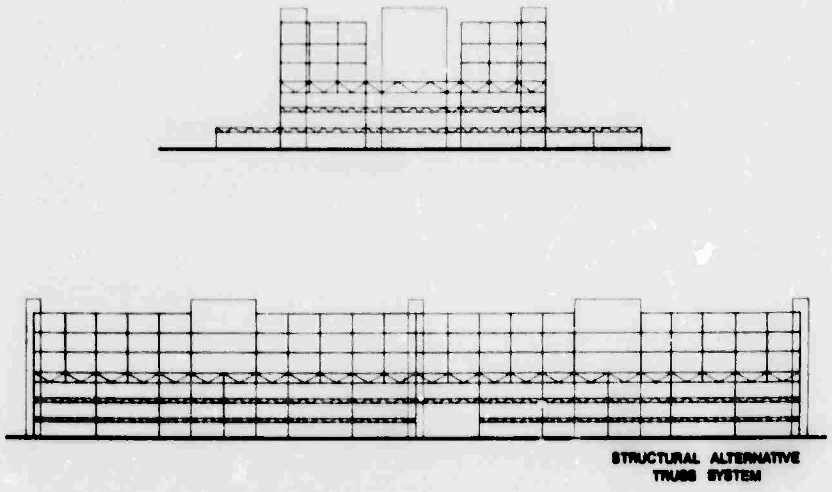


Figure 3.4-23 Two-Way Truss
Structural Alternative

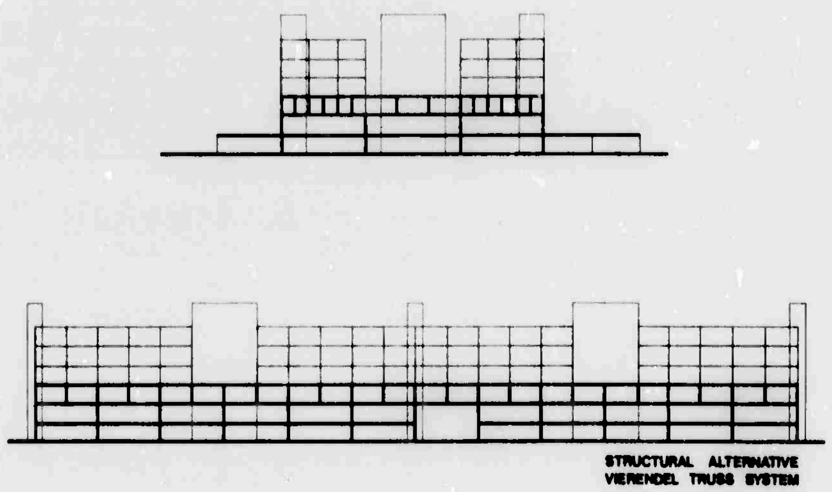


Figure 3.4-24 Vierendel Truss
Structural Alternative

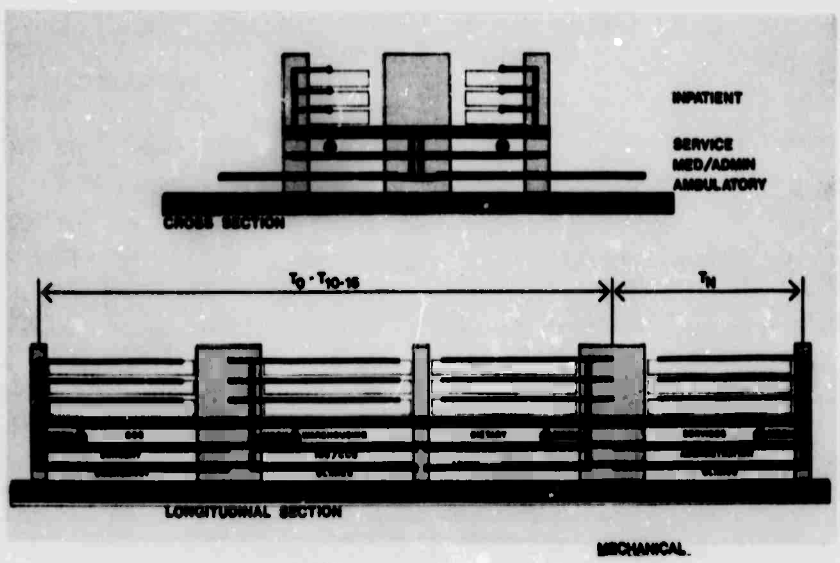


Figure 3.4-25 Relationship of Mechanical Equipment and Utilities Distribution

The service level is also the hub of materiel and supplies storage and distribution systems. This was largely dictated by its proximity to the major user of these items -- the inpatient area. Also, it is located directly above the Surgery and Delivery Suites. Supplies and services are received in the warehousing area through one of the secondary nodes, possibly in the form of a freight elevator supported by a dumbwaiter. The distribution of services from the warehousing or dietary area is through primary vertical circulation nodes (Figure 3.4-26). From these vertical nodes, the distribution pattern to each level and on each level to each functional activity is simple and direct (Figure 3.4-27). If an automated disposal system is incorporated into the BLHC System, it is included in the secondary nodes.

The Dietary pattern is specifically illustrated (Figure 3.4-28 since it represents the largest demand for materiel distribution. The diagram shows the proximity of the source to the areas to be served, and the lack of conflict of this major service flow with the other activity levels which are not dependent on dietary services but have a high degree of people circulation. The concepts of distribution are not based on specific materiel distribution hardware, but can accommodate a variety of hardware options.

<u>Vertical Nodes (Figures 3.4-29 and 3.4-30)</u>

The performance characteristics of vertical nodes have been defined in the generalized logic as the umbilical cord which links the horizontal and vertical movement of people and the distribution of services within the design logic. Specific application to Base "X" has required more detailed analysis of the functions of the nodes. The primary nodes retain their function, mechanical movement of people with elevators. Specific numbers of elevators can be tied directly to the modules of inpatient activity as a function of time; the ultimate growth capability of the total system is determined by the vertical life capability provided in the primary nodes. Each primary node also contains stairs for optional local vertical circulation. Additional functions

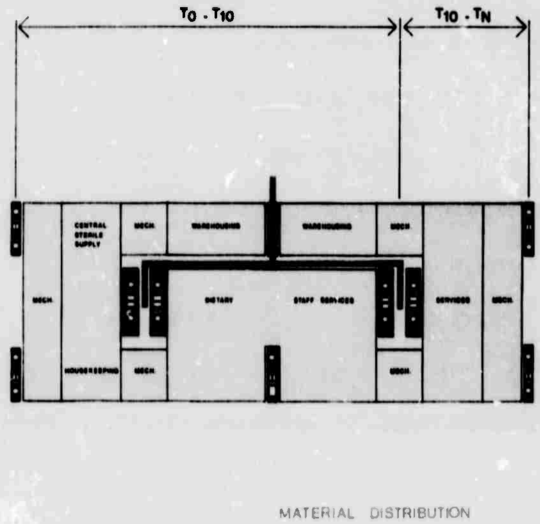


Figure 3.4-26 Primary Vertical Circulation Nodes for Services Distribution

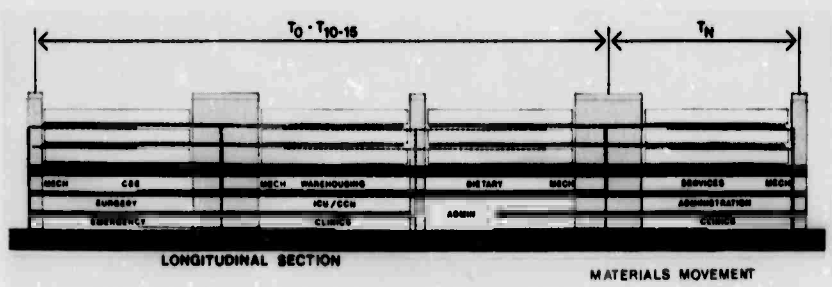


Figure 3.4-27 Materiel Distribution Pattern

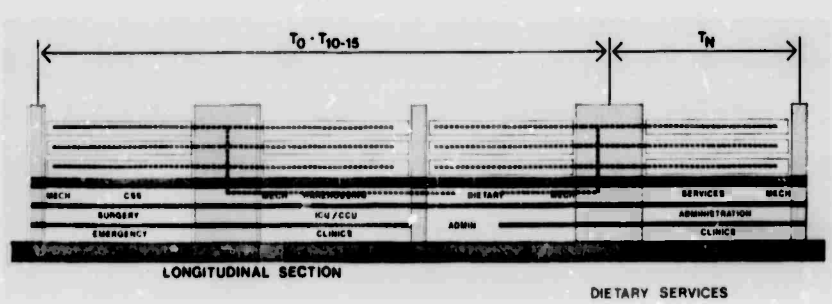


Figure 3.4-28 Dietary Distribution Pattern

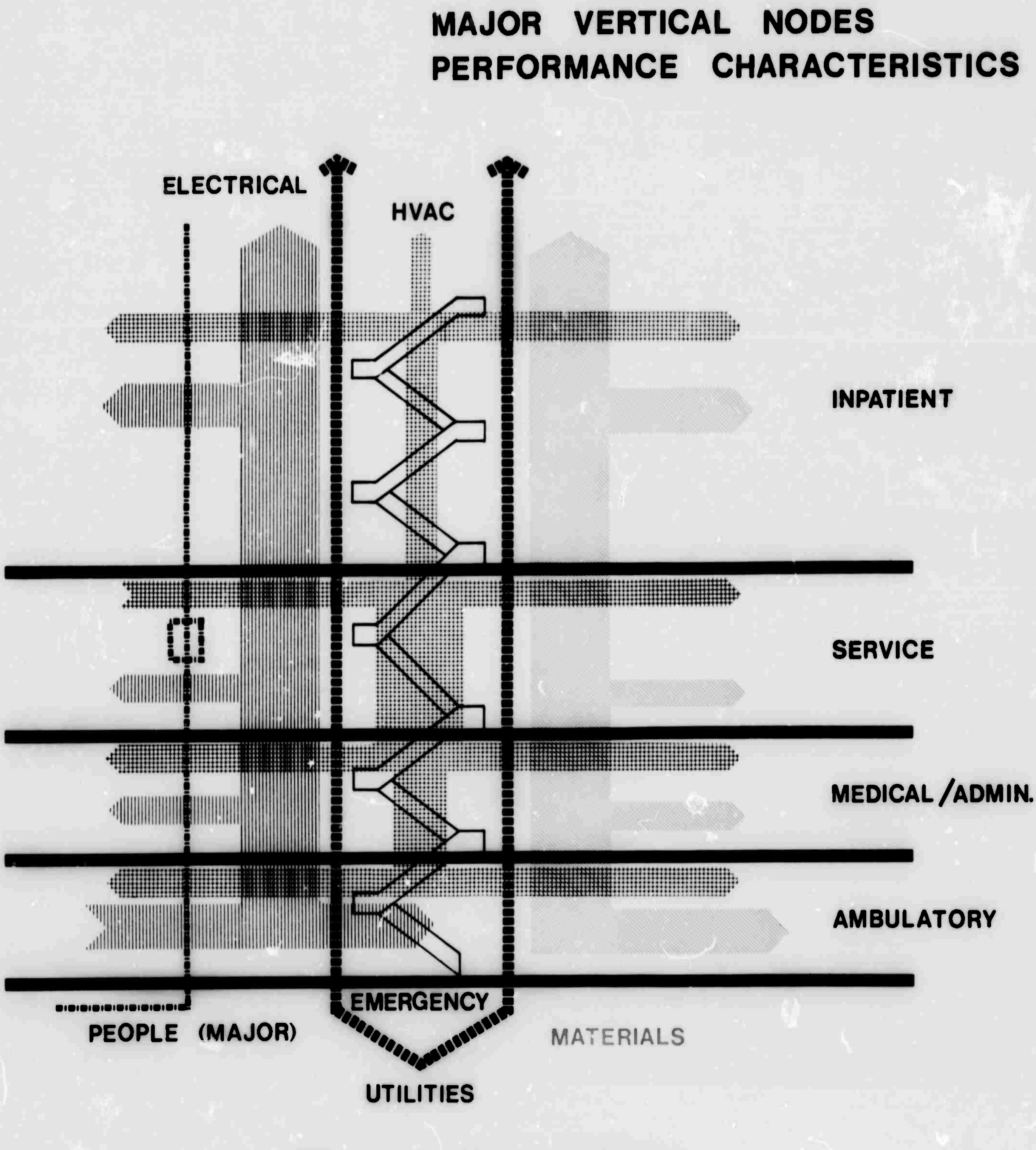


Figure 3.4-29 Major Vertical Nodes

SECONDARY VERTICAL NODES
PERFORMANCE CHARACTERISTICS

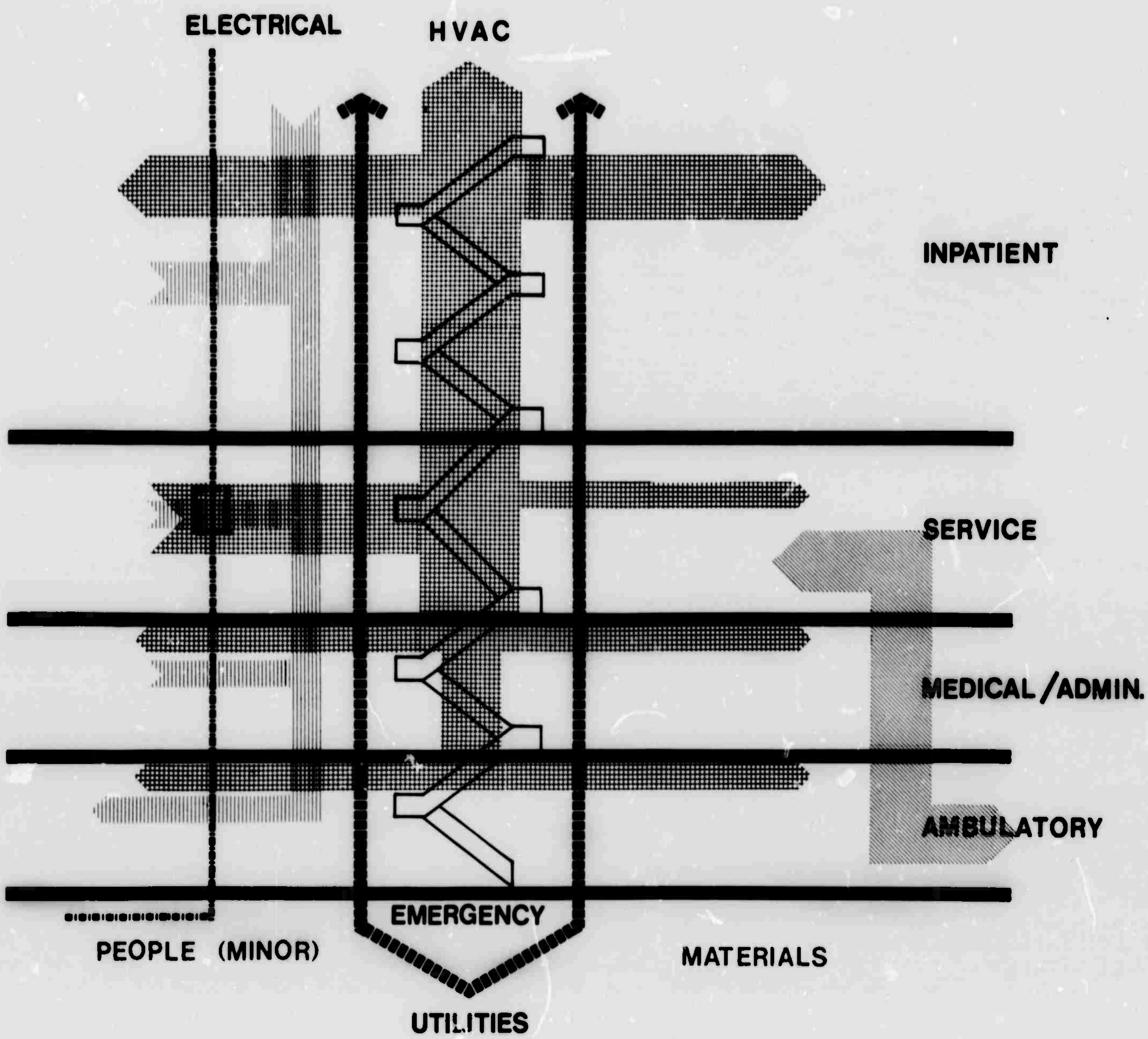


Figure 3.4-30 Minor Vertical Nodes

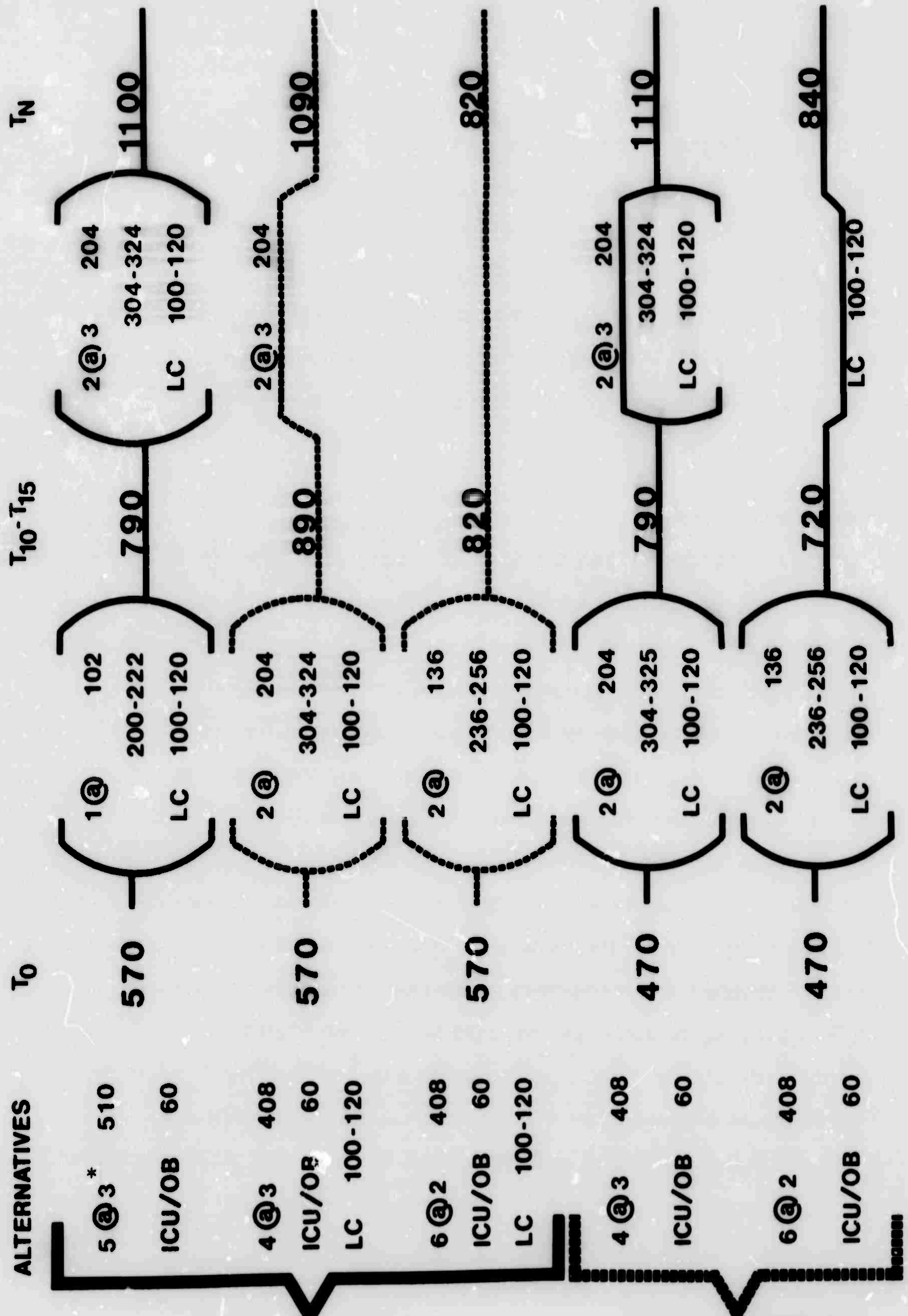
assigned to the primary nodes are materiel distribution and secondary mechanical distribution. The secondary nodes still serve as a means of local vertical people movement using stairs, but are also assigned the function of major mechanical,electrical and utilities distribution, up and down from the service level. One secondary node is assigned a freight elevator for delivery from grade level to the service level. The geometry of the nodes may also vary based on the various initial configuration options and future capability objectives.

Inpatient Elements

The inpatient demand for Base "X" can be met by several configuration alternatives, based on 2 or 3 levels of inpatient configurations combined with on-grade three level light care units. The design logic precludes adding a third level to a two level configuration after it has been built. Therefore, the initial decisions made on the configuration alternatives relative to two or three levels determine what options will be available to meet the T_{10-15} demand and thus the ultimate capability (T_N) of the system. (Figure 3.4-31.) The ultimate capability of the two level system is limited to approximately 820 beds whereas the three level system has an ultimate capability of 1100 beds. For operational flexibility, the light care function of inpatient care must be designed as a component of the inpatient configuration system to reflect the progression of patient care through the BLHCS.
Further, the ability of the inpatient system to accept swing demands from higher levels of dependency will increase administrative latitude.

As policy and budget constraints are applied to the planning process, the light care element represents the variable component of the inpatient system in terms of total demand. The on-grade light care units, therefore, are elements available for attaining the ultimate system's capacity. If a specific mission assignment can be defined initially for the BLHC System, such as medical or administrative holding, then the light care units may be considered an appropriate initial component of the system.

Figure 3.4-31 Inpatient Demand Configuration Alternatives



*5 nursing units at 3 levels

The inpatient units are designed to accept a variety of patient care and ward resource management concepts. A nominal density of 34 beds per nursing unit is assigned for the entire inpatient system, with the understanding that this number is a variable of the levels of dependency, and intensity of the medical activity related to the levels of care (Figure 3.4-32).

The patient capsule has been conceived to accept a variety of single, double, or three or four man room combinations, the variables being the space/patient ratio as allocated to the immediate vicinity of the bed, and the space allocated to the professional and nursing activity related to levels of dependency. The patient capsule (Figure 3.4-33) has three major elements:

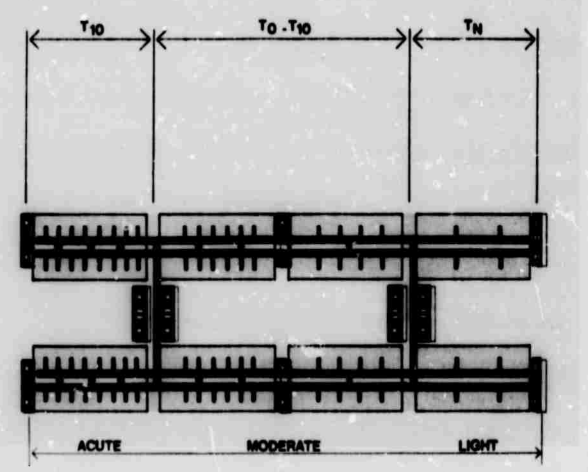
(1) Peripheral service of plumbing and mechanical services, including the shower and toilet facilities for the patient room. The necessary services are extended to the patient within "live" partitions which contain the appropriate utility elements, in addition to acting as a space divider.

(2) The second element is an "inert" partition which serves as a space divider only and may be removed to create a four bed light/moderate care room, or a four bed highly specialized intensive care unit.

(3) The third element serves as the space divider between the patient room and the professional nursing activity. These also serve as two-way cabinets for the personal effects of the patients on one side, and service/storage space for the nursing activity on the other. They are movable and can be varied to reflect the different professional space requirements of various patient dependency levels.

The location of fixed services on the periphery creates much unencumbered space in the patient care unit. The "inert" partition element is set to coincide

INPATIENT LEVEL
SYSTEM CONFIGURATION



MEDICAL ACTIVITY

Figure 3.4-32 Inpatient Level Medical Activity

MICRO STUDY
PATIENT CAPSULE

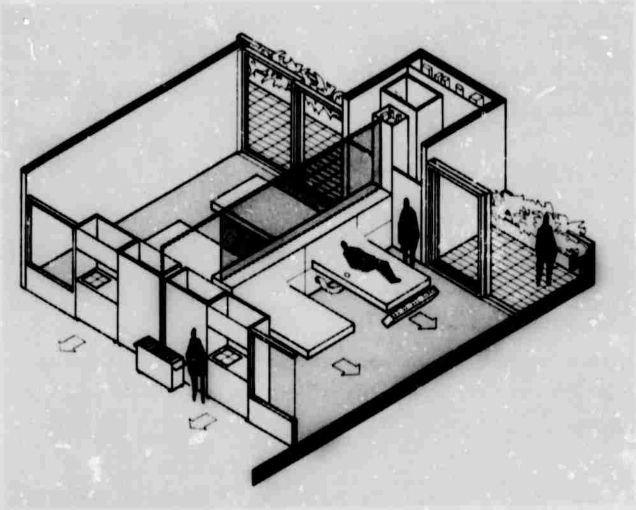


Figure 3.4-33 Patient Capsule

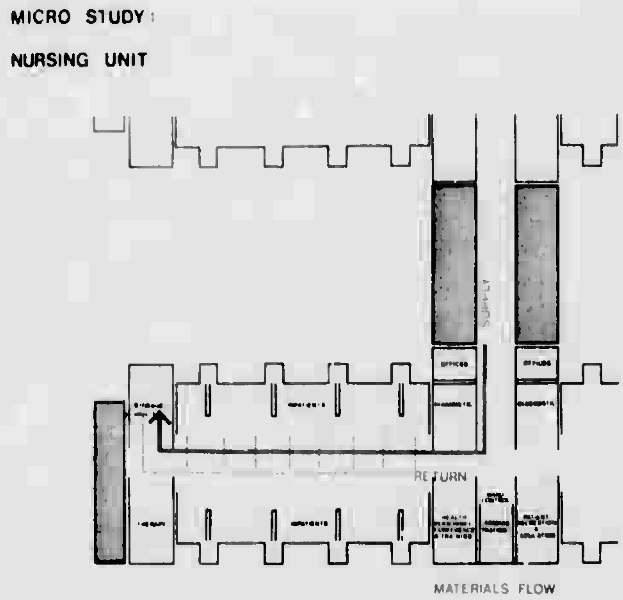


Figure 3.4-34 Inpatient Level Materiel Distribution

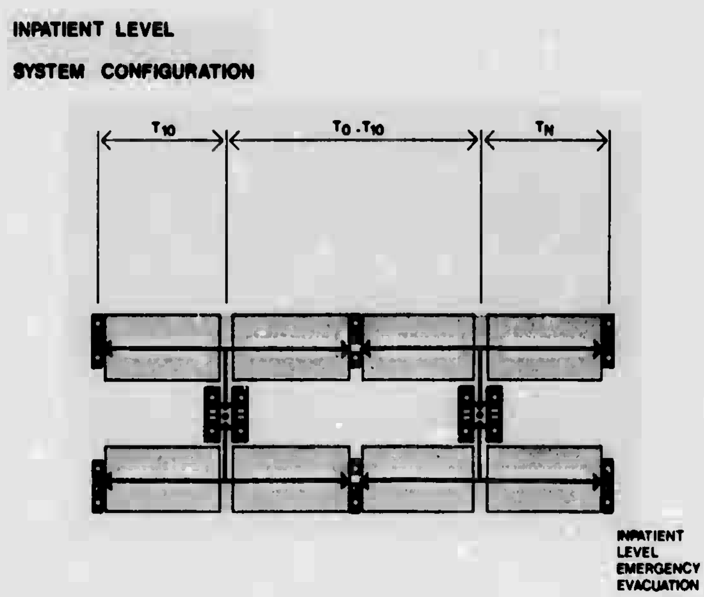


Figure 3.4-35 Inpatient Level Emergency Evacuation

with the structural framing thereby providing unobstructed vertical and horizontal paths for the mechanical services. Environmental control is provided for each room with incremental units on the periphery. Structural alternatives which provide greater clear spans may be considered if additional flexibility within the patient care unit is required.

These micro studies related to the inpatient unit, are not considered design recommendations or solutions, but illustrate the design objectives and opportunities. Based on these concepts of progressive or modified progressive patient care, they can be applied at the nursing unit scale, on an entire inpatient level, or throughout the total inpatient system.

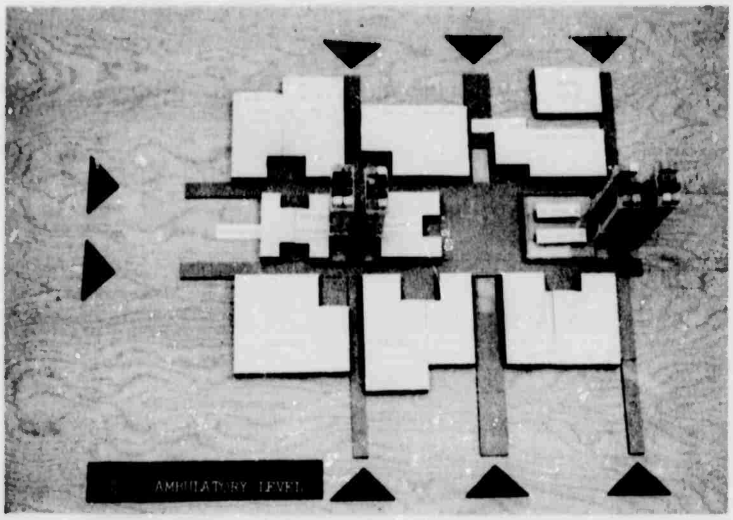
The elements for future inpatient nursing care as defined by the Medical Health Care Review Team have been incorporated into the configuration, both in specific designated areas and general purpose and unassigned spaces for responding to unique future requirements. The constant elements of the inpatient unit are those which depend on the relationships to the overall system elements such as service and materiel distribution, patient and staff flow, emergency evacuation patterns, etc. (Figures 3.4-34 and 3.4-35.)

LIFE CYCLE SENSITIVITY CHARACTERISTICS (Figures 3.4-36 thru 3.4-41)

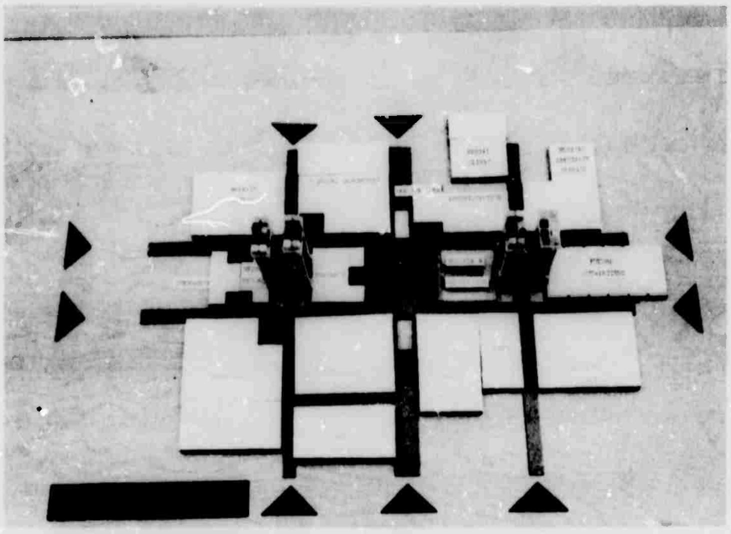
This sequence of photographs illustrates the life cycle changes of the Base "X" test configuration for each functional level related to the time frames of the two examples and the ultimate capability of the system (T_N).

FIGURE 3.4-36 AMBULATORY

T_0



T_{10}



T_N

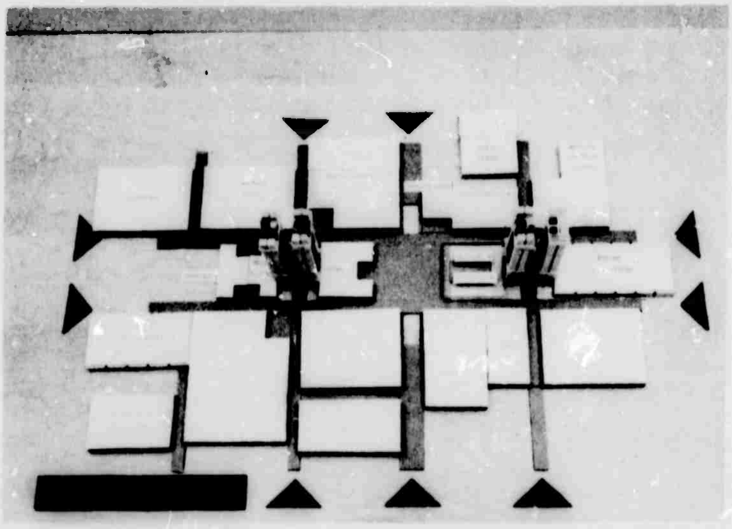
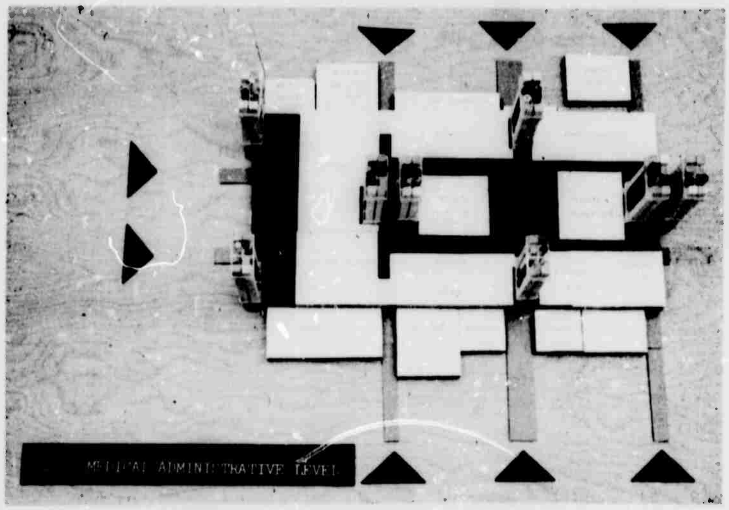
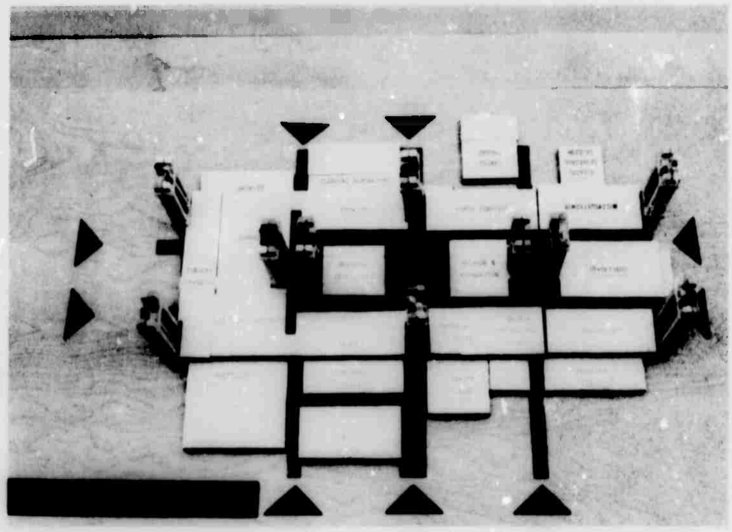


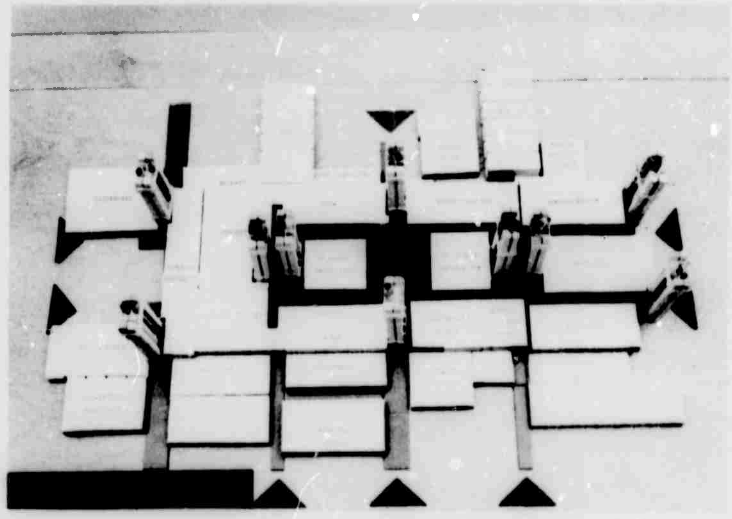
FIGURE 3.4-37 MEDICAL/PROGESSIONAL LEVEL



T_0



T_{10}

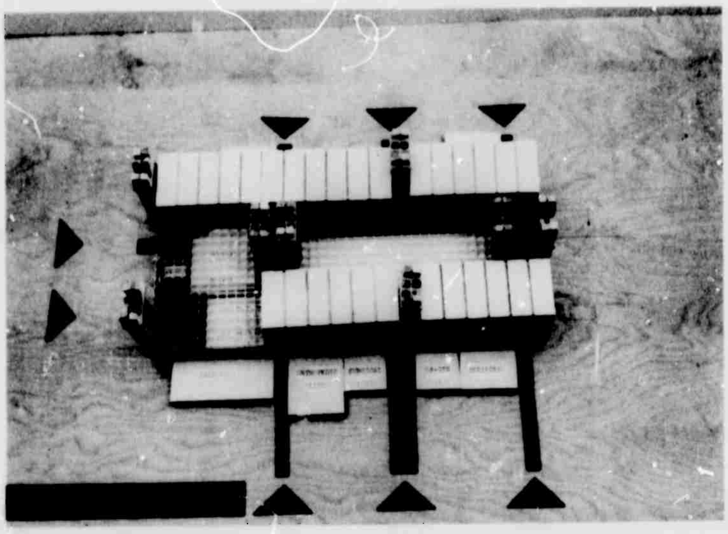


T_N

FIGURE 3.4-38 INPATIENT CONFIGURATIONS ALTERNATIVES - TOTAL POTENTIAL DEMAND

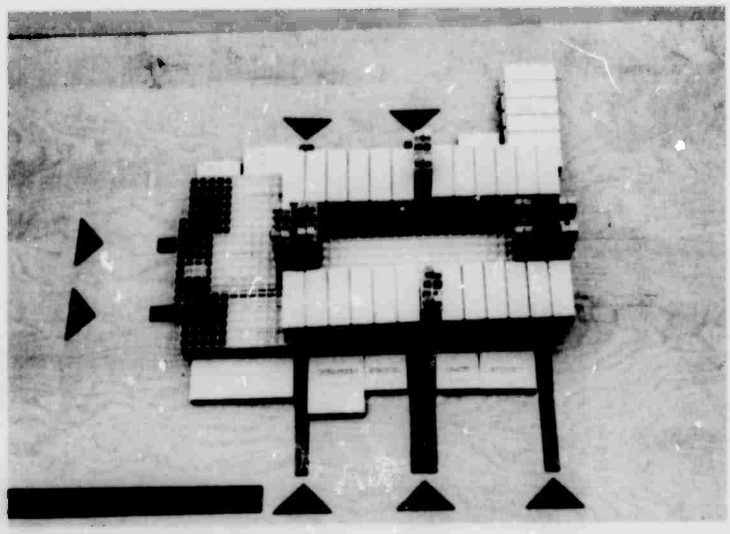
T_0

570 Beds
5 NU at
3 Levels



T_0

570 Beds
4 NU at 3 Levels
& Light Care



T_0

570 Beds
6 NU at 2 Levels
& Light Care

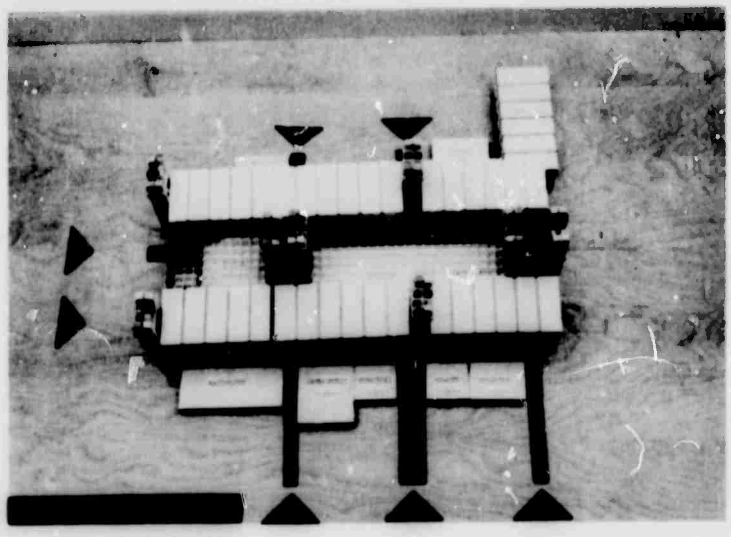
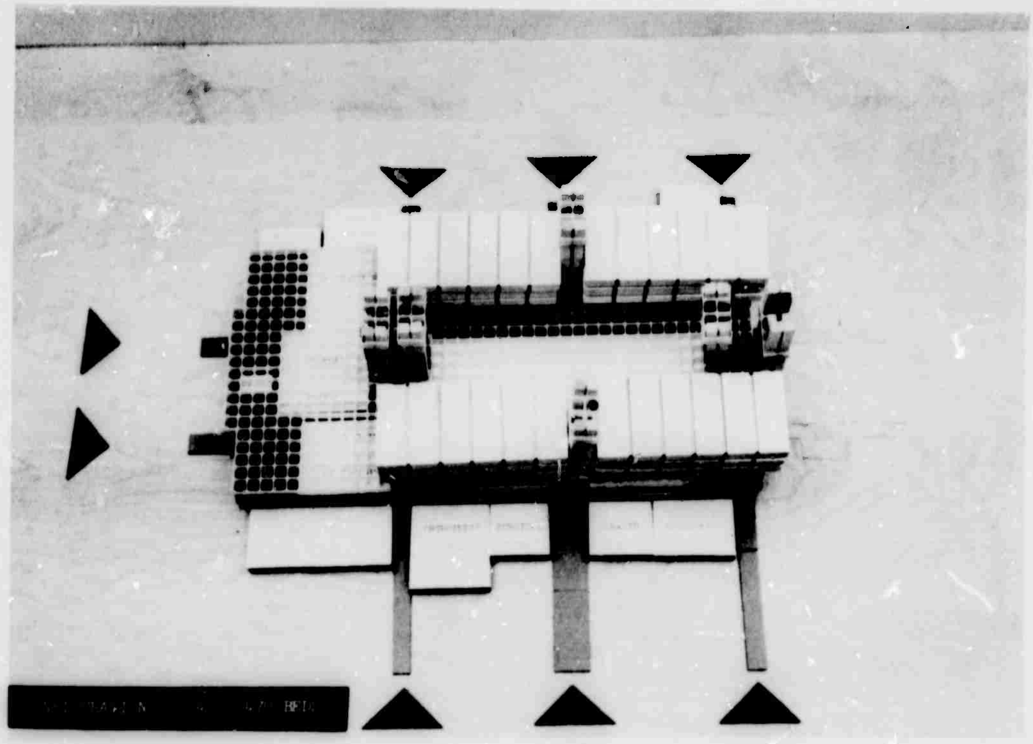
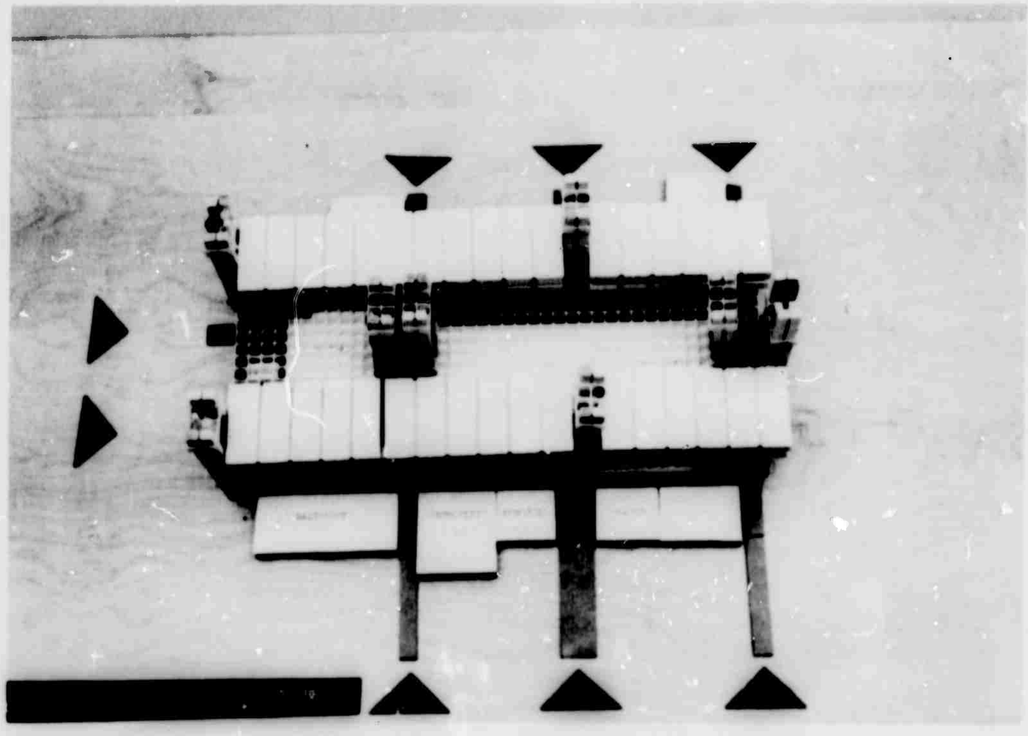


FIGURE 3.4-39 CURRENT POLICY ON UTILIZATION



T_0

470 Beds
4 NU at
3 Levels



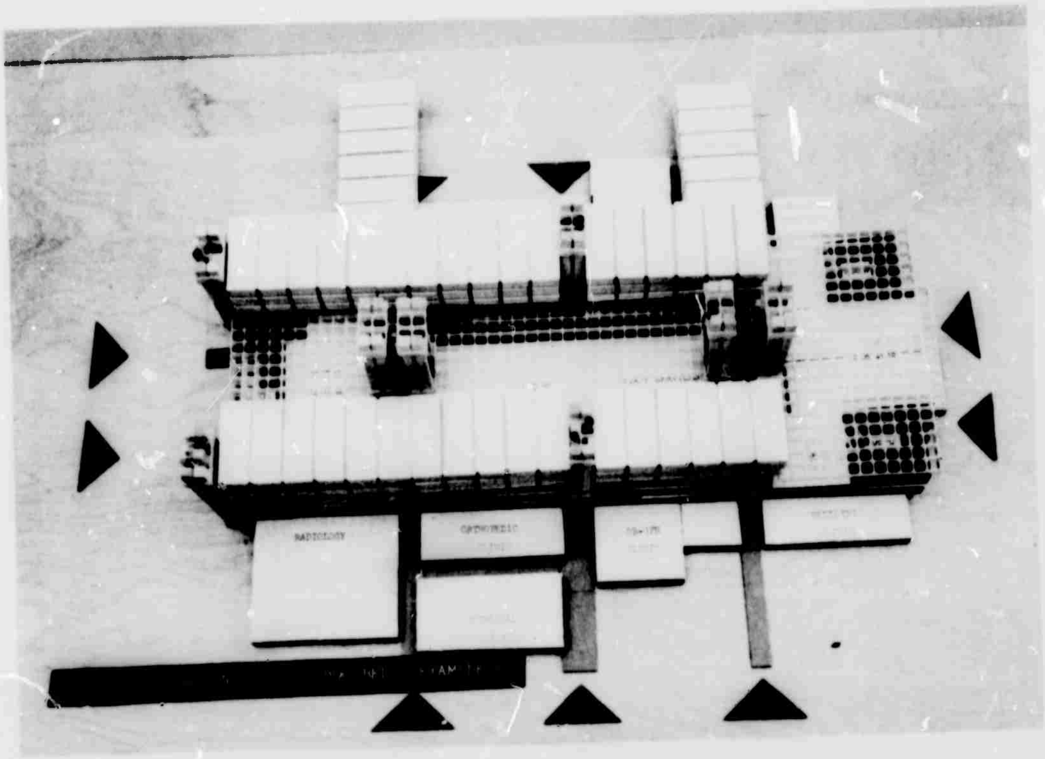
T_0

470 Beds
6 NU at
2 Levels

FIGURE 3.4-40

T_{10-15}

890 Beds
Example 1



T_{10}/T_N

820 Beds
Example 2

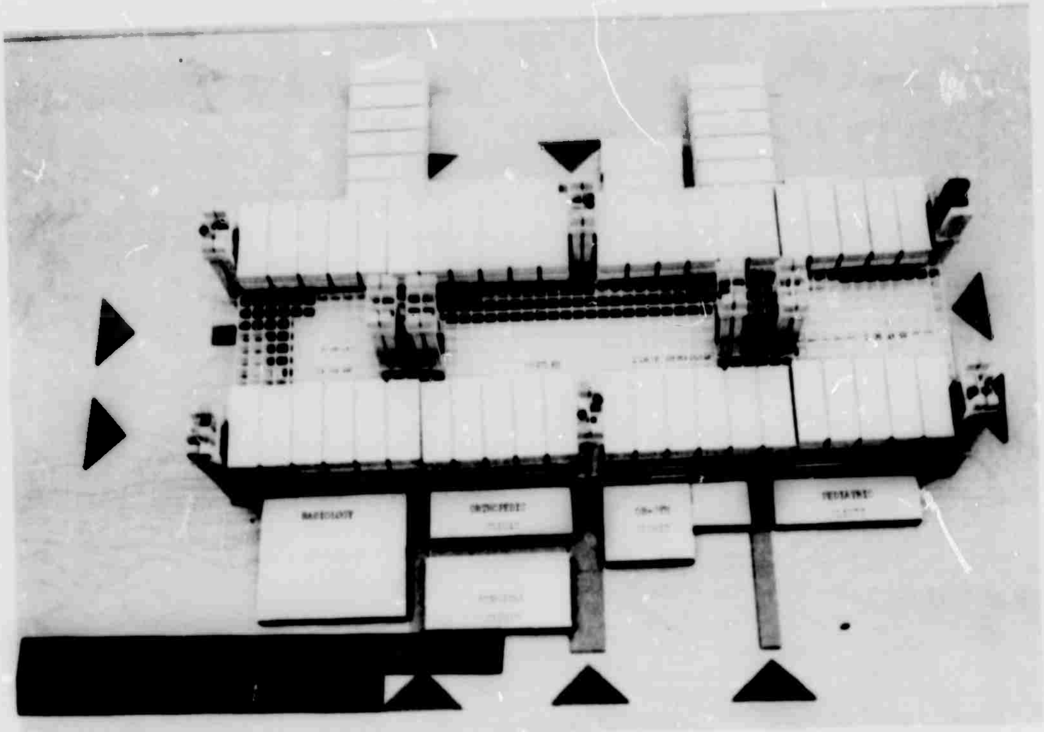


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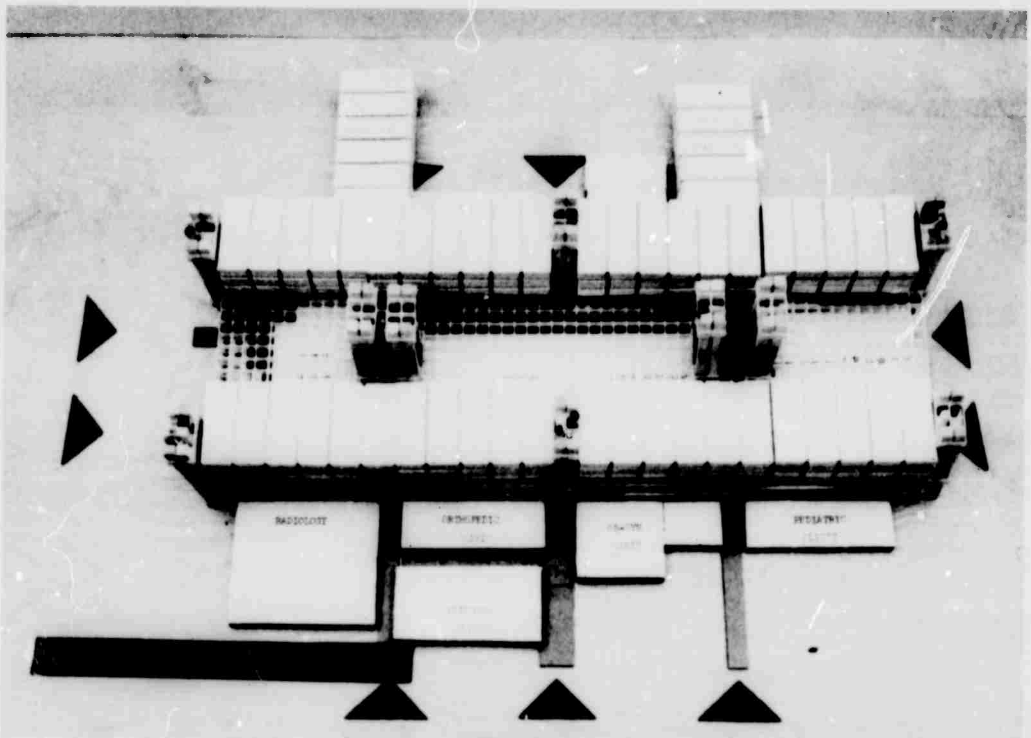
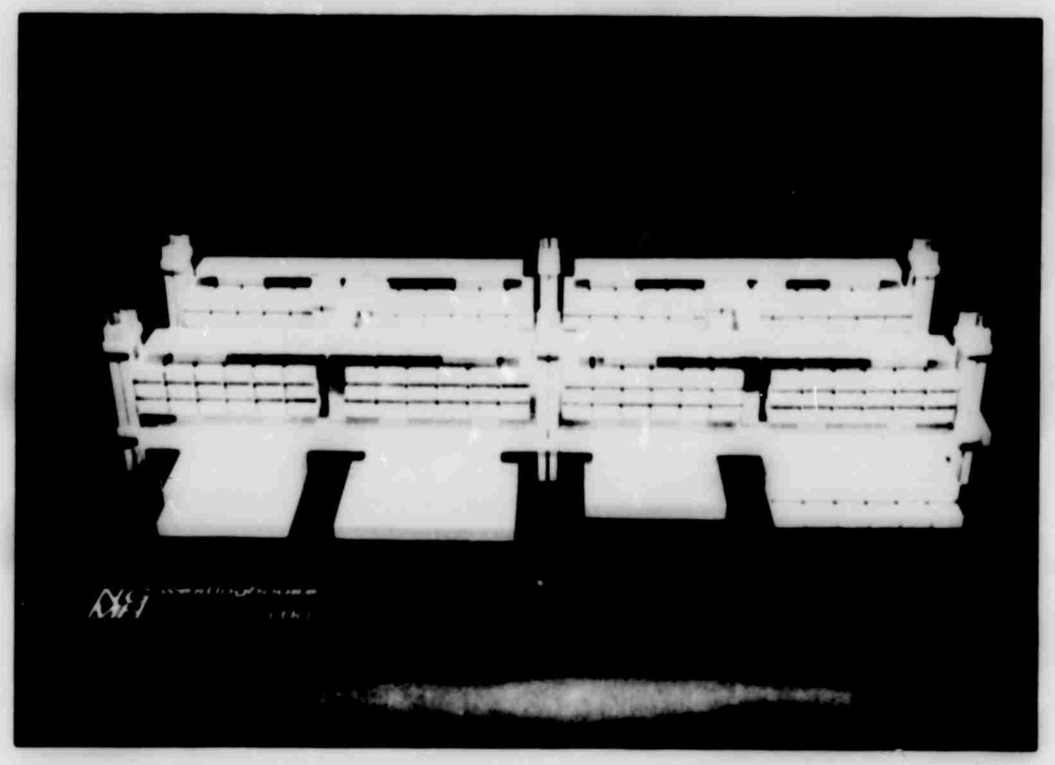
FIGURE 3.4-41 TOTAL CONFIGURATION POTENTIAL (BASE"X")



GENERAL DESIGN MODEL



Systems Characteristics	Time Function
1. BLHC System upper and lower bounds	
250 beds -- 840 beds (2 inpatient levels)	constant (T_0 - T_N)
2. Design Organizational Elements	constant
patient entry and flow pattern	(T_0 - T_N)
time/distance framework	
vertical service nodes	
primary secondary	
3. Functional Relationships and Adjacencies	
vertical adjacencies	constant
horizontal adjacencies	(T_0 - T_N)
functional location	
functional content	constant (T_0 - T_{10})
technology content	variable
Communications/Materiel Distribution	(T_{10} - T_{12})
4. Operational Content	
utilization policies	
patient mix	
inpatient/outpatient	
levels of dependency	variable (T_0 - T_N)
medical care objectives	
BLHC	
regional referral center	
teaching	
research	

The greatest variable function in the system clearly is its operational content; the configuration can accept physical growth and change requirements within the organizational logic and the upper and lower bounds of the system.

MICRO STUDIES

The ability to accept the operational variables is a function of the utilization and throughput capabilities of the sub-system elements. The operational objectives and characteristics of these elements have been illustrated with the micro studies. Specific micro studies have also investigated state-of-the-art improvement applications within the overall configuration logic.

Radiology has been found to be the most sensitive element relative to changing operational characteristics of the BLHC System. Therefore, the radiology sub-system has been defined to illustrate the state-of-the-art improvement recommendations of the radiology consultant, Dr. Lerman, and to illustrate the capability of the sub-system to grow while maintaining the basic operational patterns of patient and staff flow (Figure 3.4-42). The two corridor concept is aimed at improving the throughput capability of radiology by maximizing the productive interface between radiologist and health care demands. Similarly, increased utilization of clinic facilities is achieved by the relocation of physicians offices and incorporation of combination treatment/examining rooms into certain clinics. The flow patterns of patients and staff in the clinic facility are illustrated (Figure 3.4-43). During the detailed architectural design phase, each micro study element would undergo successive refinements in layout and space definition within the established organizational framework of flows of patients, staff, and services.

MICRO STUDY:

RADIOLOGY

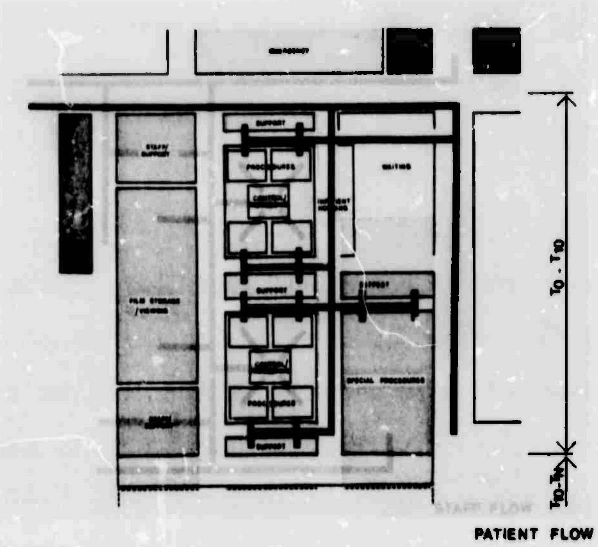


Figure 3.4-42 Radiology Patient and Staff Flow

MICRO STUDY:

CLINICS

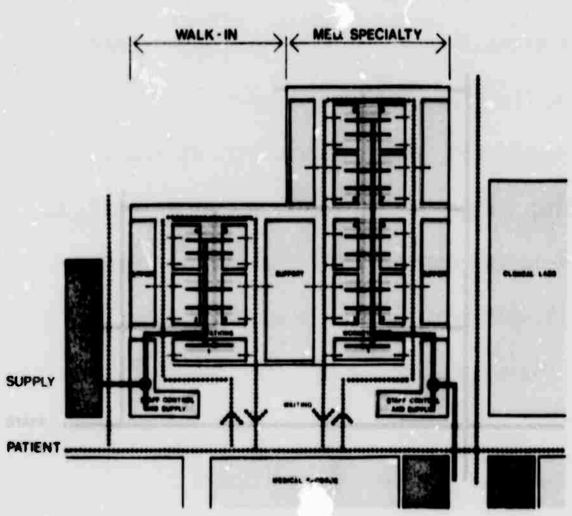


Figure 3.4-43 Patient, Staff, and Materiel Flows in the Clinics

SITE CONSIDERATIONS

The location of the BLHC System within the base master plan is contingent cn the following:

- availability of land
- relationship to existing health care elements
- relationship to beneficiary population
- relationship to transportation.

All these considerations must be evaluated and planned in the same life cycle time period as the BLHC System.

Land Availability

The availability of land must be evaluated in terms of the growth prognosis of the ambulatory zone. New facilities may expand and displace soft areas, such as parking, provided replacement space is available as well as new space for the expanded demand. Alternatively, it may be possible to consider the concept of air rights, where land is reserved to meet the contingency of future demand and all fixed improvements are planned around the reserved land. The approximate ground area coverage for Base "X" at T_0 configuration is 3 acres. The growth through the T_{10-15} to T_N time frames would raise the ground requirement to approximately 5 acres. The requirements for parking will vary based on staffing and outpatient utilization as well as the availability of alternative modes of transport on the base.

The selection of an appropriate site with land availability as a major criterion is essential to realize the potential of the design configuration. Topographic and subsoil conditions may be resolved on an individual project basis, but if space is not available for the open-ended development capabilities inherent in the design, the facility will be constrained during its entire life cycle.

Existing Facilities

The relationship of new facilities to existing health care elements is a major consideration in terms of both location and phasing. Total replacement facilities face the problem of continuity of operation, which may not imply contiguity of the new BLHC Systems. Major additions to existing facilities, on the other hand, are a more complex problem in terms of siting and phasing. They require the integration of the existing facility elements into the new organizational and operational framework. Consideration must include the forecast of the remaining effective life of the existing facilities against the performance requirements of these facilities over the life cycle of the BLHC System.

Location of Beneficiary Population

The proximity of lower echelon health care facilities to the beneficiary population should be specifically evaluated for each base location relative to the base master plan and the character of the beneficiary population. The BLHC System is not analogous to civilian health care systems in the sense of economic completion. In civilian systems, the geographic location most convenient to the consumer is advantageous. But since the competition of other health care systems is not a factor in the BLHC System, the placement of health care elements related to the consumer is based on the operational evaluation of costs/benefits of total BLHC services. The BLHC System's convenience and accessibility to the consumer is a function of the relationship to the transportation elements.

Transportation Accessibility

The major modes of transportation to the BLHC System are limited to the private automobile and the base public transportation. The majority of patients will probably use cars; generally only recruits and those portions of the active duty population concentrated in the troop housing areas will use the base transportation.

The primary access consideration, then, is the relationship of the health care facility to the base road system. The following must be accommodated:

- patients, staff, visitors
- emergency
- services.

The orientation of the composite facility relative to the primary access routes varies with each location, an external system of access and parking zones must therefore be defined relative to the design configuration (Figure 3.4-44).

Patients, Staff, Visitors Entry

The external entry system must orient all entrants to the appropriate transfer zone and entry point. The orientation of patients and visitors is a two-phase process: (1) the initial visit (walk-in) and (2) subsequent visits to discrete system elements. Staff and visitor entry can be defined in relatively predictable patterns. The ability of the system to schedule and regulate ambulatory patient entry has a direct impact on the external flow of organization.

Emergency

Emergency entry access routes must be defined and segregated to reflect the direct and urgent nature of emergency.

Service

Service is a major consideration in defining access requirements. The service flow includes delivery of materiel and supplies, as well as the disposal of waste, whatever its form. Based on the state-of-the-art forecast, service delivery will increasingly change from large bulk delivery to more discrete and more frequent service deliveries. More palletized containers will facilitate a series of shipping and transfer points, and warehousing will become more receiving and distribution than storage and preparation. The

INTERNAL / EXTERNAL
MOVEMENT SYSTEM

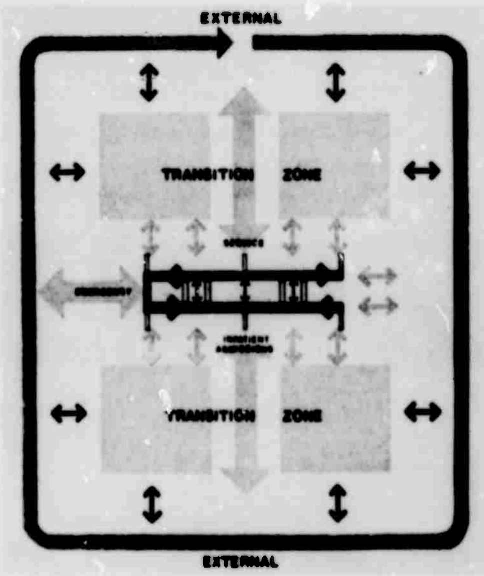


Figure 3.4-44 Orientation of Composite Facility Relative to Primary Access Routes

corollary of this trend is the increased production of waste materials by the system. The disposal of these wastes to the periphery or to an external service point is accomplished with the proposed vacuum pneumatic tube system. Further breakdown of the wastes through compaction will then facilitate the disposal process from the external service point.

The specific requirements of the various entry flows are satisfied with the external entry system. The refinements of this system in terms of signs, graphics, and visual identification systems represent a further step in the design development. An integrated internal and external signing and information system can also represent a prototype system of this kind, worthy of further specific study.

LIFE CYCLE COST ANALYSIS

Assumptions

Two major assumptions about the life cycle cost comparison of the test design configuration are:

(1) The system will accrue operating savings over its period of operation by being able to accept a variety of operational policies and organizations for utilization and staffing. Further, the system will accept new and improved methods with minimal modification and disruption of services, also resulting in savings. Since the test design will serve as a laboratory to evaluate new concepts, these are unspecified at this time and difficult to quantify beyond the specific cost/benefits which may be assigned to selected sub-system contenders.

(2) The second assumption is that major growth will occur during the life cycle of the system. And, because operating costs over the life cycle far exceed first costs, penalties in first cost are acceptable because the system configuration can accept growth within the original organizational framework.

It is further assumed that the growth will not cause major disruption and modifications and can be accommodated at a normal costing rate. The smaller differential between the initial costs of the test configuration and a conventional design, the greater the life cycle savings from the test configuration.

The analysis of the system's configuration as a function of cost indicates that the ability to assign variable cost elements to selected functional areas has resulted in an initial cost which is comparable to conventionally designed facilities. To design a facility with uniform flexibility (i.e. full interstitial spaces) throughout may be justified when the expansion and changes of a system are entirely unpredictable; but more appropriate to the BLHC System are concepts of selected flexibility and assignment of greatest change capability to the most dynamic areas of the BLHC System as defined by the data gathering effort, which is embodied in our design logic.

<u>Introduction</u>

A macro-economic approach was taken in the cost analysis of the NGMH system design. This was necessary to explore the cost feasibility of the design in terms of life cost compared to the cost of conventional hospital design. The cost of a specific configuration and method of construction at a defined location was not at issue, although the method is indicated for carrying the analysis to that level.

Thus the "test configuration" discussed in the analysis is merely representative of the general cost profile of the NGMH system design. The "conventional hospital" data presented are based on the cost files of McKee-Berger-Mansueto, Inc. and are representative of the current design/cost of military and civilian hospitals in this country. The time/location frames of the data are T_0 = U.S. 1970 and T_{10} = U.S. 1980.

Cost Analysis of NGMH (T_0)

The initial task of the analysis was to determine T_0 costs of the NGMH system design for a range of alternative structural, architectural, and mechanical solutions. These solutions were applied to a typical configuration (570 beds, 500,000 sq. ft.) to quantify the various cost relationships involved. From these data a "test"solution was selected to permit comparison with "conventional" hospital cost data. Although the building systems selected are not complete, they are representative of a range of probable solutions in terms of both cost and method of construction.

Costs were analyzed by the following building system categories:

1.0 Foundation
2.0 Superstructure
3.0 Exterior Wall
4.0 Interior Finish
5.0 Roof
6.0 Casework
7.0 Plumbing
8.0 Heating, Ventilating, and Air Conditioning
9.0 Electrical
10.0 Elevators.

Where appropriate, alternatives were analyzed within a given category, including seven alternatives under the structural category, four under exterior wall, three under interior finishes, and three under HVAC. Costs were also analyzed by level and functional area within each level.

In some instances however, building system costs and the costs of certain elements could not be appropriately distributed among levels and areas. These exceptions include the foundation, roof and elevator systems, circulation areas, primary and secondary nodes, and the distribution of exterior wall costs to interior areas.

The costs of the foundation, roof, and elevator systems have been treated as non-distributable "constants", which are added in the summary analysis of the total cost of the NGMH system. Also, because the NGMH test configuration was assumed to have a remote energy supply*, the cost of certain mechanical and electrical equipment (boilers, chillers,and towers) have been treated as constants.

A summary of the significant cost elements for the NGMH test configuration is shown in Table 3.4-10. (See Appendix 3.2-1 McKee-Berger-Mansueto Cost Analysis).

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* This assumption was necessary to permit subsequent cost comparisons with conventional hospitals to be made on a uniform basis.

TABLE 3.4-10

NGMH TEST CONFIGURATION: INITIAL COST (T_0)

(Dollars/Square Foot)

BUILDING SYSTEM	NGMH (500,000 square feet)
Foundation	$ 3.00
Superstructure (Steel frame, concrete, fireproofing and slabs)	9.15
Architectural	15.75
Roof	.85
Casework	2.00
Plumbing	3.60
HVAC	7.00
Electrical	6.55
Elevators	1.10
	$ 49.00

<u>Comparative Cost Analysis of NGMH and Conventional Hospitals</u> (T_0 and T_{10})

From the detailed T_0 cost analysis of the NGMH system design, a test configuration was selected for comparison to conventional hospital design. The configuration assumes the use of a 2-way truss structural system by U.S. Steel; exterior face brick with solid block back-up; average finishes; all-air HVAC on the lower levels and incremental units on the inpatient level; normal foundations; and standard electrical, plumbing and elevator systems.

In terms of cost, this test configuration is neither the least nor the most expensive solution that could be achieved with the NGMH system. But, as would be true of the other design solutions to the NGMH system, its primary cost feature is its flexibility for future expansion and changes at lower cost. Additional benefits and advantages are functional arrangements with adjacencies and interrelationships that enhance operational workload through-put capabilities staffing and operating costs.

Part of the cost of this flexibility is a higher first cost of the structural and architectural portions of the design, specifically, the super-structure, exterior wall, interior finish, roof and casework systems. The structural requirements of a wide span of the service level account for most of the added cost, both to the superstructure itself and to the exterior wall system as well. The latter is increased because of the resulting higher ratio of exterior wall area to gross floor area. It is also increased,though less significantly, because of the balconies at the inpatient level.

Some savings in the structural system do occur at the inpatient level, however, because of its independence from the lower level. Case-work costs are greater because of their (assumed) more widespread use in lieu of permanent interior partitions.

Foundation costs are slightly lower because the main block is rectangular and columns occur at regular intervals. Roof system costs are higher because the roof accounts for a higher gross area relative to the gross floor area.

The cost analysis of the NGMH HVAC system assumes a conventional all-air system on the lower levels, incremental units at the inpatient level, and a remote energy source, i.e., boilers, chillers and cooling towers, in a separate structure.

At the ambulatory and medical/professional levels, the analysis assumes, with some exceptions, an all-air system with terminal reheats for specific zones, and cabinet heaters, two pipes, unit heaters, or convector radiation in entries, stair halls, etc. The areas where more

sophisticated treatment is necessary include surgery, ICU-CCU, obstetrics and gynecology, and the main operating suites.

Multi-zone equipment with terminal reheats are adequate for all-air installation; ICU-CCU and obstetrics and gynecology can be heated and air conditioned with all electric incremental units beneath the windows. Make-up air for these areas can be supplied from corridor duct work, with exhaust through the toilet rooms; direct exhaust is necessary for all-air zones. The functions of the HVAC system at the service level normally occur at the basement level in conventional hospitals. Air handlers, pumps and miscellaneous equipment whose weight does not require excessive structural alteration are assumed to be on this level. Piping loops for both hot and chilled water supply and return are found at this level, feeding down to the medical/professional and ambulatory levels and up to the inpatient floors. The service level HVAC system is assumed to be all-air, with some perimeter treatment where required. Cafeteria and kitchen areas require the most sophisticated treatment at this level.

For maximum flexibility, the room treatment at the inpatient level is based on the utilization of incremental units beneath the windows. These are self-contained heating and cooling units with integral controls. They require only wall penetration and electrical connections; no piping is required in the perimeter areas. This equipment does not place any load on central heating and cooling gear. Interior floor areas are assumed to be all-air for environmental control, make-up air and exhaust. Make-up air will be provided to patient rooms, and exhausted through toilets. Interior areas will be multi-zoned with reheat coils where required.

The cost of the HVAC system is increased approximately 5 percent by the built-in provisions for more economical future expansion such as larger duct and pipe sizes. Nevertheless, the NGMH HVAC system costs

less overall as a result of the use of incremental units at the inpatient level (which were assumed because of their greater flexibility).

The analysis of the NGMH plumbing system assumes standard building requirements throughout, but the cost is substantially lower than that of a conventional hospital plumbing system. This saving results mainly from the central location of the service level and the use of perimeter service piping in the inpatient level.

The grouping of the functions performed at the ambulatory and medical/professional levels into two levels in the NGMH reduces the necessity for dense interior piping for medical gasses and acid. When these functional areas are widely dispersed, as in most conventional hospitals, interior piping becomes quite dense, and costly because of the high labor input required for installation. The perimeter layout in the NGMH also lends itself to more economical expansion.

The grouping of equipment at the service level confines the main piping to one distinct area. Conventional design would locate certain equipment in the basement and other equipment, such as that found in the kitchen area, elsewhere. This increases the density and hence the cost of the piping.

The NGMH configuration at the inpatient level tends to keep service piping at a minimum by running it at the perimeter of the building, thus reducing first cost and permitting more economical expansion. The placement of the toilets in the perimeter rather than the interior does not affect the first cost of the system. This placement does, however, keep the interior entirely clear of any large lateral or vertical runs of pipe, providing much more flexibility to the interior space, and thus permitting more economical alteration. Approximately 3 percent of the first cost of the NGMH plumbing system is accounted for by built-in provisions for future expansion.

Strategic placement of the elevators in the primary nodes efficiently serves a greater floor area in the NGMH than would the banks in a conventional hospital, reducing the square foot cost of this system.

The slightly higher cost of the electrical system in the NGMH test configuration is the result of built-in provisions for future expansion.

The quantified results of the comparison between the NGMH test configuration and the conventional hospital is shown in Table 3.4-11. The costs of the conventional hospital are derived from the data files of McKee-Berger-Mansueto, Inc. and represent an approximate average of many civilian and military hospitals built throughout the U.S. since 1968. These basic data were adjusted for time and location and any unusual site conditions or special requirements. In these, and subsequent comparisons, hospital equipment costs have been asterisked.

TABLE 3.4-11

First Cost (T_0)

Comparison of Construction (1): NGMH and Conventional Hospital

(Dollars per square foot - Present Value)

Building System	NGMH	Conventional
Foundation	\$ 3.00	\$ 3.10
Structural (2)	9.15	7.85
Architectrual (3)	15.75	14.30
Roof	.85	.65
Casework	2.00	1.50
Plumbing	3.60	4.35
HVAC	7.00	7.65
Electrical	6.55	6.35
Elevators	1.10	1.25
TOTAL	\$49.00	\$47.00

(1) Does not include hospital equipment.

(2) Assumes U.S. Steel Scheme

(3) Includes cost of Exterior Wall (\$3.0) and Interior Finishes (\$4.0).

The economic significance of the NGMH system design is revealed when an expansion of the test configuration is assumed to occur and its cost is compared to the cost of a similar expansion in the conventional hospital.

For this part of the analysis, an equal change in demand at T_{10} was assumed for both the NGMH and the conventional hospital. The Demand Model determined the exact nature of the expansion -- what and how much of each area at each level would expand.

At T_0, the total square feet of building area in the NGMH system, because of its flexibility and additional services, is about 10 percent greater (500,000 square feet) than in the conventional hospital with the same medical capability (450,000 square feet.) However, the expansion of the conventional hospital would require, because of its fixed design, an area comparable to an entire new wing (240,000 square feet). To provide equivalent services, the NGMH system would require an expansion area of only 187,000 square feet, a difference of 53,000 square feet.

Furthermore, as the following table shows, the per square foot expansion cost of the NGMH system is only slightly more than the T_0 square foot costs. In contrast, the expansion of the conventional hospital would cost approximately 40 percent more per square foot than the initial structure.

Approximately half the difference between the costs of the two expansions is in the mechanical, electrical and elevator systems; the remainder represents alterations to the existing structure.

Alterations to the existing structure represent a substantial cost in conventional hospital expansions in addition to the disruptions caused to services. In Tables 3.4-12 and 3.4-13 these costs are prorated over the area of expansion.

TABLE 3.4-12

Expansion Cost (T_{10})

Comparison of Construction:[1] NGMH and Conventional Hospital

(Dollars per square foot - Present Value)

Building System	NGMH (187,000 S/F)	Conventional (240,000 S/F)
Foundation	$ 3.00	$ 3.85
Structural [2]	8.75	8 35
Architectural [3]	17.70	17.75
Roof	1.40	1.10
Casework	2.40	1.75
Plumbing	2.67	5.05
HVAC	5.27	8.25
Electrical	5.47	7.60
Elevators	1.00	2.15
Alteration Adjustment [4]	3.81	10.07
TOTAL	$51.47	$65.92

(1) Does not include Hospital equipment.

(2) Assumes U.S. Steel Scheme.

(3) Includes cost of Exterior Wall ($3.0) and Interior Finishes ($4.0).

(4) Alteration to existing structure prorated over expansion area.

TABLE 3.4-13

Alteration of T_0 Structure at T_{10}
(Costs per square foot)

Building System	NGMH	Conventional
Architectural	\$24.38	\$21.89
Structural	-	5.19
Plumbing	3.11	6.23
HVAC	15.15	21.48
Electrical	15.67	19.09
	\$58.31	\$73.[illegible]
Area affected:	25,357 square feet	68,070 square feet

To provide an effective measure of the cost feasibility of the NGMH system, the total of first costs (T_0) and expansion costs (T_{10}) of the test configuration and the conventional hospital were compared. These totals were derived by discounting first costs at a rate of 10 percent per annum for the cost of money; inflating expansion costs at a rate of 12 percent for 1970 and 1971, 8 percent for 1972 and 1973, and 6 percent for 1974 to 1980. The first cost and the expansion cost were weighted by the square feet area involved and this sum discounted back to T_0.

The analysis indicates that a real savings of \$2.12 per square foot would accrue from the use of NGMH system if the assumed 36 percent expansion occurred at T_{10}.

Further analysis shows that if the same expansion occurred at any point between T_0 and T_{20}, the total costs of the NGMH system design would be less than the total costs of the conventional hospital. Significant variations in the assumed discount and inflation rates do not alter this conclusion. (Table 3.4-14)

TABLE 3.4-14

COMPARISON OF CONSTRUCTION COSTS

NGMH AND CONVENTIONAL HOSPITAL

(Dollars per square foot)

	NGMH		CONVENTIONAL	
	Present Cost (1970)	Future Cost (1980)	Present Cost (1970)	Future Cost (1980)
First Cost (T_0)	\$49.00	\$127.05	\$47.00	\$121.91
Expansion Cost (T_{10})	\$51.47	\$106.75	\$65.92	\$136.77
Total Cost (1)	\$46.84	\$121.58	\$48.96	\$127.05

(1) Weighted cost of T_0 plus T_{10} adjusted for inflation and cost of money.

SUMMARY OF BASE "X" CONFIGURATION COST EVALUATION

The analysis indicates that the initial construction costs of the NGMH system design will, in most instances, be the same or only slightly higher than the initial construction costs of conventional hospital design. The expansion (alteration and addition) costs of conventional hospitals, however, will be substantially higher than the expansion costs of the NGMH. In fact, the difference is so significant that, if expansion does occur, the total construction cost of the NGMH system design will be lower than the total construction cost of conventional hospital design.

These comparisons are shown in Figure 3.4-45

"Total construction cost" means the weighted sum of first costs and expansion costs adjusted for the cost of money and inflation.

(1) Westinghouse has demonstrated that the design logic is capable of generating configurations for Base "X" which meet the Demand Model performance requirements of growth and change over the life cycle selected, as shown in the T_0 -- T_{15} figures. These configurations have further capabilities to grow and change, prolonging their useful life, as shown in the T_N figures.

(2) These configurations were generated using current DoD design criteria for all functional elements; they only slightly exceed current criteria in the major circulation areas. This enlarged circulation capability is essential to the design logic and is absorbed during the growth of the facility. In fact, the expansion steps would require less space than normally needed for conventional design.

(3) Westinghouse demonstrated that the estimated construction cost of a facility resulting from the use of this design approach is competitive for first cost analysis with a conventionally designed facility; furthermore, this difference in first cost is more than justified by lessened future cost in response to change and growth.

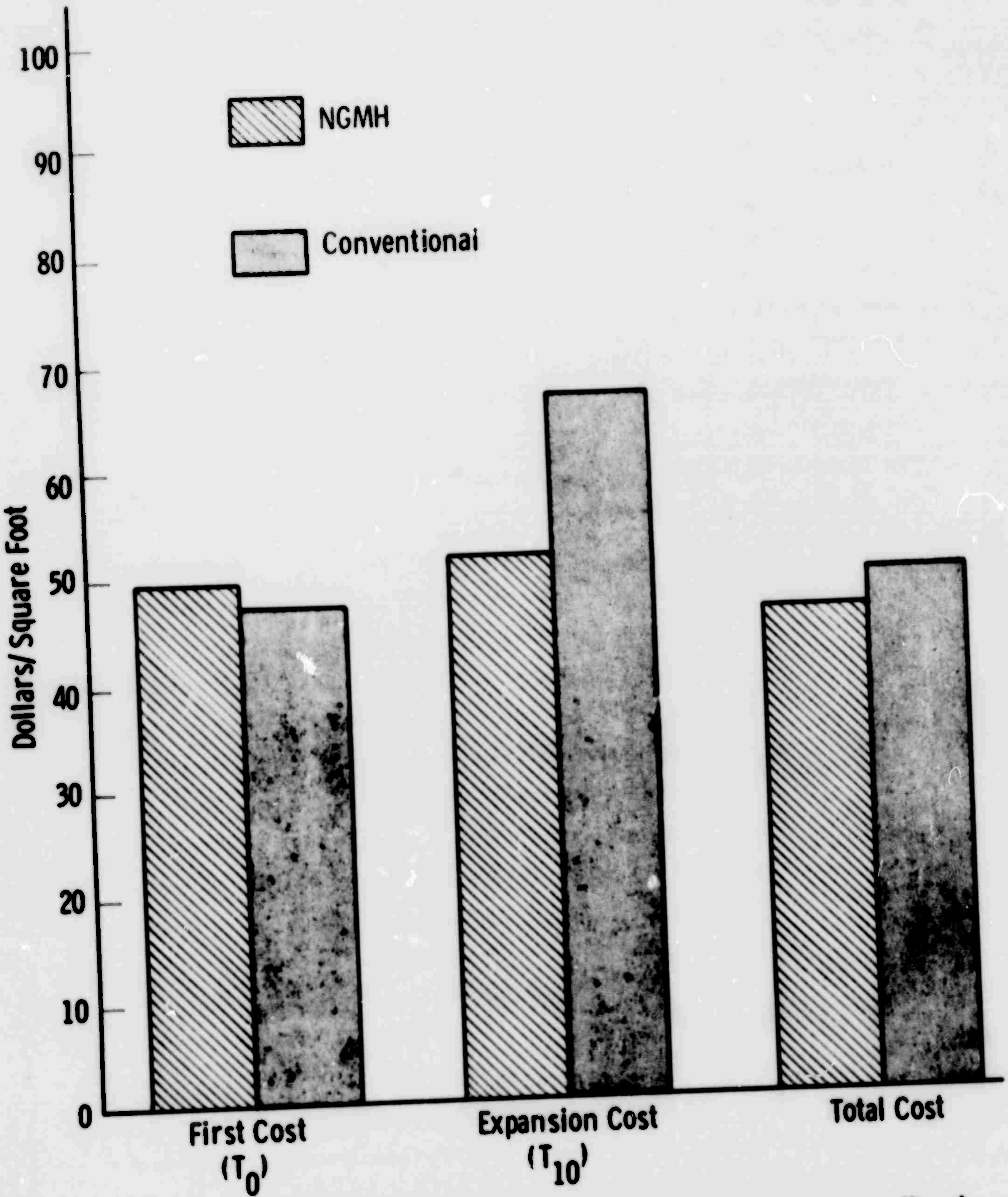


Fig. 3.4-45—Comparison of construction costs NGMH and conventional hospital (dollars/ SF - present value)

(4) Finally, the design logic can accept all the operational improvement contenders into its overall organizational framework. It is, therefore, a valid test vehicle to assess the real impact of these alternatives.

IMPROVEMENT ALTERNATIVES (Table 3.4-15)

A number of operational recommendations can now be evaluated against the specific needs of Base "X" to calculate their contributions to more efficient and effective performance. These recommendations, which will result in less space and/or personnel in some cases, have the following estimated effects:

Dietary

A combination of convenience foods and abbreviated kitchens will be substituted for the conventional dietary system in the Base "X" current design. Base "X" savings for this alternative are difficult to compute precisely because major population changes will occur 10 to 15 years after its initial opening. However, they can be estimated as follows:

- Approximately 3,500 square feet less space will be required for the dietary function at T_0 and 6,000 square feet less at T_{10}/T_{15}. This represents a reduced investment of about \$120,000 and \$180,000 respectively.
- Approximately six fewer dietary personnel will be required at T_0 compared with a conventional system and approximately nine less at T_{10}/T_{15}.
- Approximately \$8,000,000 savings will be realized in total life cycle costs over 25 years, assuming stated inflation and cost of money.
- The cost per inpatient-bed-day will be lowered approximately \$2.72 for all levels of patient dependency.

Materiel Handling

A manual exchange cart system will be instituted for the delivery of all supplies and linens. The use of automatic dumbwaiters are not justified, since the convenience food option will be used to handle the dietary load and resulting

load peaks, and no savings are expected for the supply side of materiel handling.

However, a pneumatic waste disposal system will be initially installed in Base "X", even though this will slightly increase operating costs per year by approximately $8,000 per year, or 6 percent for this function, which will be more than balanced by reductions of approximately 15 percent in the materiel handling personnel. An increasing use of disposables for dietary utensils and linens of all types are anticipated although present day costs do not justify their usage. Use of disposables will also contribute to lowering system sensitivity to escalation in the cost of labor and increased scarcity of labor. This alternative can be conveniently accommodated in the secondary nodes, but only during initial construction; it will not require increased space in the facility design.

Data Management and Communications Systems

An automated communications and data management system, as manufactured by National Data Communications (REACH System), will initially be installed in Base "X". While this system will not produce as much savings in the early years of operation as the IBM MISP system, it can be upgraded to assume more data management and communications functions than the IBM system. Therefore, as the hardware and software developments are achieved and added to the REACH system, the initial advantage for the IBM system will disappear.

The introduction of this system into Base "X" will result in a life cycle cost savings of approximately $4,650,000, with a potential for greater economies as improvements are added to the system. In addition, if some of the subjective items -- for which specific economics could not be estimated -- also contribute to cost savings, this will increase its impact. It is estimated that this alternative will save approximately $238,000 in the first year of operation in the inpatient area and $36,000 in the outpatient area, and reduce the space required for filing and record storage by approximately 9,000 square feet.

Ward Management

If staff is assigned to Base "X" by the staff estimating process recommended in the analysis, it will result in approximately 10 fewer ward management personnel at T_0, and approximately 13 fewer at T_{10}/T_{15} than with the current method. The estimated life cycle cost savings resulting from this change is $1,000,000 with approximately $170,000 saved in the first full year of operation.

Studies also indicate that leveling the ward workload by changing some of the traditional work assignments and interacting more successfully with ancillary services and outpatient clinics, could further reduce staff by approximately 10 at T_0 and 14 at T_{10}/T_{15}. This would produce a life cycle cost saving of approximately $1,000,000 with savings of approximately $72,000 in the first year of operations. This improvement will also probably result in some small reduction in facilities although its impact has not been estimated.

Dentistry

Assuming that approximately 470,000 dental procedures per year are performed at Base "X" at T_0 and 600,000 per year at T_{10}/T_{15}, the introduction of the recommended operational alternatives will yield a life cycle cost saving of approximately $9,400,000 and result in a saving of approximately $670,000 in the first year of operation.

Radiology

Assuming that the Base "X" radiology workload is approximately 230 procedures per day at T_0 and that the workload triples over the full life cycle of the analysis, Westinghouse estimates that the approximate life cycle savings to be gained by introducing a two-corridor layout is approximately $1,100,000 with expected economies in the first year of operation of approximately $73,000. The productivity increase will allow the space criteria for this operation to be lowered and effect a saving of approximately 2,000 square feet at T_0. Another area of cost savings is in the reduction of two operating rooms at T_0 and at least another $120,000 savings in first cost from installing two generators serving multiple X-ray machines instead of one for each machine.

Pharmacy

There are two basic recommendations in this area: (1) use of a unit dose system in the inpatient area and (2) automatic dispensing for high-volume simple prescriptions in the outpatient department. For Base "X" unit dose system should result in a life cycle saving of approximately $950,000 and the automatic dispensing approximately $75,000. Both of these alternatives will result in a total of $75,300 savings in the first full year of operation as well as some decrease of space for the pharmacy function although the amount has not been calculated.

Clinical Laboratories

Westinghouse recommends that the clinical laboratory be increasingly automated and specific machine/manual replacement charts be developed for specific volumes of laboratory tests by department. For Base "X" approximately $600,000 can be saved over the life cycle of the system by using this approach, approximately $34,000 in the first year of operation. The increased use of automated equipment will also require smaller laboratory space and at T_0 this reduction will be approximately 2,500 square feet.

Education and Training

An improved O.J.T. program is recommended for Base "X" based on a dial access system with many dispersed access points which use a central data base and displaying programs on a television screen. This alternative will produce life cycle savings of $950,000, including about $64,000 in the first year of operation. This alternative will not affect overall facility size.

Outpatient Clinics

Westinghouse recommends several improvement alternatives for these areas: multiple use of facilities, extended hours of operation, increased numbers of examination rooms for some physicians, and the treatment of a large percent of surgical procedures on an out-patient basis.

Base "X" life cycle savings resulting from these alternatives will be approximately $1,650,000 with savings of approximately $98,000 in the first year of

operation. These alternatives will also require less space for the same outpatient capacity, reducing space by approximately 10,000 square feet at T_0.

TABLE 3.4-15
Summary of Improvement Alternative Cost Savings

Operational Alternative	Estimated Life Cycle Savings ($)	Estimated 1st Year Operating Cost Savings or Losses ($)	Estimated T_0 space reduction square feet
Dietary	-8,000,000	-455,000	3,500
Materiel Handling	+ 100,000	+ 8,000	-
Data Management and Communications	-4,650,000	-238,000	9,000
Ward Management	-2,000,000	-142,000	*2,000
Dentistry	-9,400,000	-670,000	*2,000
Radiology	-1,000,000	- 73,000	2,000
Pharmacy	- 950,000	- 75,000	*1,000
Clinical Laboratories	- 600,000	- 34,000	2,500
Education & Training	- 950,000	- 64,000	-
Outpatient Clinics	-1,650,000	- 98,000	10,000
TOTALS	$28,300,000	$1,841,000	23,000 square feet

*Preliminary estimate

We have estimated that the operating cost for the first full year at Base "X" will be $10,560,000 if conventional staffing and operational procedures were used. The following shows the breakdown of the operating budget for three major categories for present criteria and decrease with Base "X" recommendations.

Present Criteria	Base "X" Recommendations
• $5,580,000 inpatient activities	$ 991,000
• $3,720,000 outpatient activities	$ 180,000
• $1,360,000 dentistry	$ 670,000

The total savings shown can be subdivided as follows -- inpatient activities $991,000; outpatient activities, $180,000; and dentistry, $670,000.

The improvements also resulted in a decrease in the overall size of the facility required at T_0 for Base "X" by approximately 32,000 square feet with a reduced construction cost of approximately $1,650,000. All the space saving is gained inside functional elements of the system. As a result, the total facility size is reduced to less than 5 percent more space than would be built using current criteria and design methods for the same demand, while still retaining all the flexibility and circulation of the new design logic. This makes the economic justifications relating to construction cost even more attractive.

The life cycle cost savings were difficult to compute accurately for the Base "X" example because of the major size increase to be accommodated at T_{10} and T_{15} for the two population examples. Some improvement alternatives will become more effective as the scale of the facility increases; particularly for the data management and communications alternative, technology and programming changes will increase the expected savings.

ADDITIONAL PLANNING/DESIGN CONSIDERATIONS

The application of the Westinghouse study outputs to planning and design of Base "X" has illustrated both the processes and interrelationships involved for each major area of the study. The application has been limited to those study outputs which are fully justifiable at this time, within the limits of the data available for analysis.

Two other major issues relating to the planning and design of inpatient areas have potential application in Base "X" as a prototype facility for the next

generation of military health care facilities. These two issues involve:

(1) Assigning the number of inpatients to a ward based on their level of dependency.

(2) A more sophisticated method of proceeding from a demand statement of average daily patient load to gross numbers of beds to be constructed.

Although Westinghouse has not been able to completely analyze their effect, the design logic developed in this study has demonstrated its ability to respond to these approaches.

Differential Patient Occupancy by Ward

After analyzing the patient care requirements for each level of dependency with the associated staff, space, and environmental needs, Westinghouse has concluded that inpatient density may vary from 48 patients to a light care ward, 34 patients to a moderate care ward, and 16 patients to an acute or heavy ward, assuming that these wards are designed as shown in the design logic. The major determinants of quality of care are level of staffing and environmental standards. The professional corridor has a movable inner wall for each patient module; the peripheral locations of utilities and support sub-systems in the design permit these patient densities to be attained.

In the T_0 configuration for Base "X" the inpatient area excluding O.B. nursing unit and the ICU/CCU unit has fifteen 34-bed nursing units comprising a total of 510 beds. Assigning patients to wards by dependency levels as shown above for predicted Base "X" patient mix would require two 16-bed nursing units for acute care; seven 34-bed nursing units for moderate care; and five 48-bed nursing units for light care. Without having lowered the nominal capability of the inpatient area, this would result in a saving of one nursing unit of approximately 11,500 square feet and a first cost saving of approximately $450,000.

New Approach to Allocation of Total Beds

The traditional method for allocating the total beds to be constructed is to divide the estimated or predicted demand (stated in terms of average daily census) by an occupancy rate of 80 percent. Since this approach is intended to account for the variation between average and peak demands, it generally leads to the construction of more capacity than is required.

The Westinghouse approach assumes that the dynamics of patient entry and flow through a BLHC System can be described in a valid mathematical form (See pages 3.1-51 to 57). Briefly, the beds required at any average census are arranged by level of care against a listing of the probability with which this number of beds could always accommodate the demand. The health care planner can then select a level of certainty related to level of care and evaluate the implications of building the facility only to this capacity.

Assuming a reasonable percentage of light and moderate care patients can be rescheduled, and if the facility is designed so that staff and patient densities can be revised easily to accommodate short-term overdemand, a nominally smaller facility should be able to perform at a consistently higher utilization rate and, in effect, have the same throughput as a larger facility.

The results of applying this approach to Base "X" are:

- Demand Model average daily census by levels of care at T_0 are:

ICU/CCU	=	4.36
Heavy Care	=	33.94
Moderate Care	=	194.77
Light Care	=	221.24
Total	=	454.31

- Nominal beds using 0.8 occupancy factor = 570
- Alternate beds based on probability functions

ICU/CCU	=	12	(at 99.94% Certainty)
Heavy Care	=	53	(at 99.87% Certainty)

Moderate Care	=	216	(at 93.73% Certainty)
Light Care	=	232	(at 77.75% Certainty)
Total		513	

- This would result in the provision of 60 less beds or two less nursing units (Pages 3.4-13 + 14 show computer output for full array of beds and certainty levels for Base "X").

At T_{15} (for Example 1)

The same approach would lead to a provision of 100 less beds or a little more than three less nursing units.

There are considerable construction cost savings to be gained if either or both of these approaches are adopted for general use. Neither approach has been included in the cost savings for Base "X" since both need further refinement before they are generally applied. However, there is sufficient time available prior to construction of the Phase II facility, referred to in the RFQ as a "prototype", to resolve these issues.

Policy Decisions

- Admissions. The Westinghouse Demand Model is intended to provide the service health care planners with a comprehensive statement of potential demand from the entire beneficiary population of a specific BLHC System. Policy decisions which limit the planner/designer team from providing this capability will result in the unmet demand being accommodated in other health care systems at higher cost. These costs are directly absorbed by the DoD in many instances and should be related to the BLHC System.

  Using the "Fraction Served" Demand Model input, the new demand related to such policies and the differential in the unmet demand can be generated. This was done for Base "X" and the facility size recomputed to match this requirement configuration. Data is included

in the Systems Design section to illustrate the differential. (Shown on pgs. 3.4-52 - 53). The other major disadvantage associated with planning for less potential demand, is that systems which attempt to cope with oversaturation conditions inevitably become ineffective as the management and scheduling systems are strained and circumvented. Unmet demands, therefore, should be treated as a penalty to the BLHC System.

- Discharges. The Demand Model is based on data from within the BLHC System of the DoD and, to a much greater degree, on data obtained from the primary and secondary study hospitals. One of the factors evidenced at many BLHC Systems was long lengths of stay in light care by recruits and active duty military, indicating that "well" people are being retained in the health care system for basically administrative reasons rather than being discharged and treated on an outpatient basis. (Their numbers are generally large by comparison to the BLHC System but minuscule by comparison to the base population). Reductions in facility size have been calculated for reasonable reductions in the length of stay in light care and for reductions to a level comparable to that observed in civilian systems for the savings in both first and operating costs.

Dynamic Planning Program

Westinghouse has developed a proprietary planning tool, based on dynamic programming, which is capable of integrating all the performance and cost statements of planning, design configuration, and operations related to BLHC Systems, and generating expected total life cycle costs from the selection of any number of overall strategies adopted by the planner/designer team. This program is also capable of portraying the "penalty" costs which should be associated with unmet demand; the uncertainty associated with predictions of demand; the effects of alternative admissions and discharge policies; new approaches to patient density and gross size of facility; the impact of delays in construction of new capability, changing economies for construction and operations, and budget constraints on construction. The program output is given in present value dollar life cycle costs.

The success of a tool as complex as this is related to the adequacy and accuracy of the data base. The NGMH study has provided an excellent opportunity for obtaining data relating to operating and "penalty" costs. (These data, however, require further refinement, particularly the portrayal of operating cost characteristics of the system operating at satuation or over capacity.) Westinghouse believes this methodology to be valid and believes that this type of strategy analysis should be applied in the military. (The dynamic planning algorithm is detailed in Appendix 3.4-2.)

The following data base was generated for Base "X":

a. Acquisition and Modification Costs. A matrix with several thousand design configuration options was generated, describing the space and costs which would be incurred using the newly developed design logic and current criteria for each functional element.

   Each configuration option was stated in terms of medical care capacity for each major element of the system, i.e., 408 inpatient area beds in four blocks of three story inpatient units with a nominal total of overall density of 34 beds; percentage of light, moderate and heavy care patients being accommodated; number of surgery suites; size of related nursery and delivery facility; number of ICU and CCU beds; size of service level floor; number of total outpatient visits and visits to specific clinics; number and capacity of X-ray rooms; and size and capacity of clinical labs, etc. For each alternative an evaluation notation was developed to determine if that alternative was possible to arrive at from any other configuration and, if so, the cost involved in doing so.

   With this massive data base configurations which match the health care needs of any system at any time against certain criteria of throughput and utilization can be selected rapidly. Each element of cost notations can be quickly varied to reflect local cost variations and different construction technologies. Major sub-systems and

medical equipment are treated as separate items which apply to any configuration alternatives, such as elevator costs, central boiler, and refrigeration and electrical distribution equipment.

b. Operating Costs. The Westinghouse data base was developed to provide the following operating costs for a typical BLHC System:

- Cost/inpatient bed day for each level of care, including apportioned costs for administration and support services.
- Costs/outpatient visit, including apportioned costs for administration and support services.
- Cost/procedure in the ancillary services as a charge to either inpatient or outpatient area.
- Operating costs for the facility; for example, energy and maintenance.

c. "Penalty" Costs.

- Internal to the System. When a facility is not capable of meeting a health care demand, the computer searches out alternative patterns of use for the same facility. The facility may have more beds at one level of care than are needed and which could absorb the overage. Temporary overtime operations or increased patient densities are also options which may be used. Operating cost penalties are incurred for operating in this mode and these have been estimated.
- External to the System. When all such options have been exhausted and the system cannot accept any additional load, the excess demand for health care must be rescheduled (where possible) or met in some alternative system. In the latter case, cost is a true penalty which the DoD must evaluate, particularly when the alternative systems' cost for equivalent care is considerably higher than in the BLHC System. CHAMPUS data have been used to calculate these penalties.

For Base "X" (or any other situation where similar data can be described) the application of this tool was accomplished as follows:

a. The Demand Model was used to generate the total potential health care requirements of the beneficiary population at the various planning intervals of the life cycle.

b. An array of configuration options inherent in the systems design concept and which spanned these requirements was selected from the overall matrix using current criteria.

c. Operating and penalty costs were developed for each mode of operation using Functional Cost and CHAMPUS data to reflect the present system.

d. A set of programming "rules" were built into the program to reflect such items as construction labor escalation rates; operating labor escalation rates; discount rate of money; and probability factors relating to the correctness of prediction in demand over time.

e. The program was then run without any constraints: for example, if the facility could be built immediately a significant change in demand was observed; construction and operating decisions were always based on meeting the total potential demand; and there were no budget constraints. This was done for both population examples at Base "X", and the computer printouts indicated the "theoretical optimum" construction and operating strategies to be adopted in each example. The optimal strategy would obviously be that course of action resulting in the least expected life cycle cost.

f. The next series of programming runs were generated with constraints representing the real-life problems of any major planning and construction process, i.e., the delay which occurs between the planner's perception or prediction of altered needs and the beneficial occupancy of the facility designed to accommodate these needs. DoD experience was used for these factors. Least life cycle costs

generated with these constraints were used to select "practical optimal" strategies which form the basis for comparison of any alternative programs.

g. The major advantage of any computer-based strategy evaluation tool is its ability to accept alternatives and rapidly portray the expected consequences. For Base "X" the following issues were selected for analysis:

- The effect of introducing the operational improvement alternatives detailed above, which not only alter operating costs but affect the space criteria for functional elements and supporting elements such as equipment rooms. These changes were effected by a complex readjustment of spaces and costs in the configuration matrix and by the overall changes to the Functional Cost for outpatient visits and cost/inpatient bed day by level of care.
- The effects of budget constraints. The T_0 configuration at Base "X" using current criteria was estimated to cost approximately $19 million to construct the configuration selected as optimal.

a) Current Criteria Examples

Population 1

Planning Interval:*	1	2	3	4	5
Basic Example	$16.75 Million	0	$4.5 Million	None	0
Tighter Constraints	$14.98 Million	0	$3.75 Million	None	0

Population 2

Planning Interval*	1	2	3	4	5
Basic Example	$16.75 Million	0	None	$2.00 Million	0
Tighter Constraints	$14.98 Million	0	None	$1.40 Million	0

*5 year intervals for each planning interval.

b) New Criteria (Associated with the Operational Changes Recommended) Examples

Population 1

Planning Interval:*	1	2	3	4	5
Basic Example	$15.40 Million	0	$3.65 Million	$0.85 Million	0
Tighter Constraints	$15.00 Million	0	$2.65 Million	$0.85 Million	0

Population 2

Planning Interval:*	1	2	3	4	5
Basic Example	$15.00 Million	0	$3.25 Million	$1.65 Million	0
Delayed Funds	$15.00 Million	0	$1.65 Million	$3.25 Million	0
Tighter Constraints	$15.00 Million	0	$1.80 Million	$0.85 Million	0

*5 year intervals for each planning interval.

- The effect of delays in the planning/construction process.
- The effect of using "current" admission policies. These policies result in facilities which are smaller and less costly initially but result in large penalties for treatment of the unmet demands in alternative systems.

The fractions of population served which were used to represent current practice for the inpatient area are:

FRACTION OF THE POPULATION SERVED

Recruits	Active Duty	Dependents of Active Duty	Retired	Dep. of Ret.
1.00	1.00	0.75	0.10	0.10

- The effect of changes to discharge policies as reflected by shortened lengths of stay in light care. The Demand Model currently contains lengths of stay in this category of 21.2 days for Recruits and 19.7 days for Active Duty Military. To test sensitivity these were reduced to 16.2 days and 14.7 days, respectively, for the analyses.

- The effect of variable patient density by level of dependency. The configurations developed for Base "X" are based on an average patient density of 34 patients/nursing unit. For this analysis, 16 patients/heavy care unit; 34 patients/moderate care nursing unit; and 48 patients/light care nursing unit were used. Intensive care and obstetrics nursing units are not included in this change.
- The effect of using the probability distribution method instead of a gross utilization factor for arriving at total beds from average daily census. In the Base "X" current criteria configurations, the gross facility size is arrived at using an 80 percent utilization factor. For this alternative the probability method and levels of certainty illustrated in the text for Planning were used.

The results of these computer runs for Base "X" Population #1 example only are:

1) With No Budget Constraints, current criteria and present methods of operation, and all the potential demand being met the least life cycle cost is achieved by building the facility with the following capability:

T_0 - 30 ICU/Acute care beds
268 Moderate care beds
272 Light care beds
370,000 outpatient visits per year

T_5 - 30 ICU/Acute care beds
340 Moderate care beds
306 Light care beds
370,000 outpatient visits per year

T_{10} - 30 ICU/Acute care beds

384 Moderate care beds

374 Light care beds

500,000 outpatient visits per year

T_{15} - 45 ICU/Acute care beds

452 Moderate care beds

408 Light care beds

500,000 outpatient visits per year

This will result in a total expected life cycle cost of $275 million.

2) If all the operational alternatives recommended are introduced into this facility, the expected life cycle cost would be $246.94 million or a total expected savings of $28.04 million. This correlates with the $28.3 million estimated in the operations section above.

3) This figure was arrived at using an average annual escalation rate for construction of 7 percent. Life cycle costs are affected as follows if this is not an adequate allowance:

8% + $1.06 M

9% + $2.56 M

10% + $3.31 M

11% + $5.31 M

Larger increases will be observed in the life cycle costs for the current criteria example.

4) The effects on expected life cycle costs and penalty costs for increasing delay in the provision of facilities to match the increased demands beyond five years are shown below:

Increased Delay	Increase in Life Cycle Costs ($ M)	Increase in Penalty Costs ($ M)
1 year	1.00	5.6
2 year	1.04	5.75
3 year	1.07	5.92
4 year	1.11	6.12

Larger effects would be seen in the current criteria example.

5) The effect of budget constraints on the expected life cycle cost is difficult to summarize because of the complex interrelationship between delays and escalation rates. However, for the basic example budget constraints applied to the optimal course of action (such as 5-year planning/construction cycle and assumed escalation rates) the expected life cycle cost would be increased by approximately $1.02 M in penalty costs alone. This figure would increase for every departure from the best strategy. When tight budget constraints are imposed, life cycle cost is increased by $3.2 million.

6) The effect of reducing the length of stay in light care to the levels stated above for recruits and active duty military would be:

- Current Criteria facility life cycle cost (optimum strategy) $275.00 million
  New Criteria facility life cycle cost $246.94 million
  Reduced length of stay in new criteria facility $239.50 million

The following qualitative conclusions summarize the numerical results of Dynamic Planning:

1. There is considerable correlation between the actual life cycle cost savings predicted by this method and the savings estimated from the parametric analyses used in the operational alternative section. This correlation is even more remarkable when it is considered that the dynamic programming tool is not fully refined; the tool uses conservative construction cost data: and not all the effects of varying operating efficiencies and costs can be fully portrayed in the program.

2. This tool is valid for evaluating alternative strategies and is considerably more valuable than any manual procedure because the major concern in any long-range planning effort is to establish the relative order of magnitude of the results of any one course relative

to any other, in the shortest possible time. Once a data base is established and proven valid, the task of inputting numerous examples is relatively simple and not lengthy.

3. Some broad conclusions which were developed by experience in other sections of the study have been verified:

- The length of time required to proceed from planning start to occupancy of the facility is a major determinant of penalty costs and increased life cycle costs. The current average time of five years used to portray the present military procedure must be shortened; the tools generated for this study are capable of contributing to this end.
- The application of budget constraints to construction costs are usually a false economy even under the best of circumstances and our assumptions of cost escalation rates are conservative. When current construction costs are escalating at 12-15 percent annually (almost twice the rate used) the effects are magnified. In addition, medical costs in civilian systems are escalating faster than in the military. The penalty costs generated in this analysis, therefore, really understate the problem. Budget cuts for construction inevitably create increased penalties and, thus, each action is reinforcing an increased life cycle cost.

CONCLUSIONS

The example of a hypothetical Base "X" has applied the tools Westinghouse has developed. The value of this example to DoD lies not so much in cost savings computed for a particular (if imaginary) BLHC System as in demonstrating that qualitative and quantitative comparisons of alternative policies, plans, designs, and subsystems can be performed in advance of the construction and operation of a facility. Simultaneously, the example shows that the tools can be applied to specific cases.

The Demand Model allows health care planners to break away from the mold of the past in predicting patient care requirements, by relying on projections of population. The NGMH design organizes the physical structure of the hospital so as to have flexibility in the rapidly changing ambulatory area while retaining low-cost inpatient wards. Future growth in demand is accommodated by an orderly expansion of capability without disrupting the physical organization of the BLHC System. The Dynamic Planning tool evaluates alternative strategies of initial construction and expansion so as to minimize total expected life cycle costs even when faced with uncertainties in projections of population. Finally, the operational subsystems are each evaluated on the basis of life cycle cost to meet the predicted demand.

This set of tools is here combined into a comprehensive methodology which, when applied to a particular BLHC System, will reduce the cost of medical care while maintaining or improving the quality of care.

APPENDIX

APPENDIX 3.1-1

PROCESSING OF AIR FORCE TAPES

OVERVIEW OF SYSTEM

In response to our request, the Air Force sent Westinghouse six reels of magnetic tape, each containing 817,560 records. Each record contained the medical history of every patient staying in an Air Force hospital during CY67. Each record was unique except in cases where the patient had multiple diagnoses; in this case, the record was duplicated except for the diagnosis information.

The aggregating of this data was done using the following population attributes:

1) The primary disease or condition of the patient
2) The beneficiary type - i.e., the type of patient receiving attention
3) Patient's sex
4) Patient's age as grouped into an appropriate range
5) Single or multiple diagnosis
6) Whether surgery was performed on the patient

In analyzing the Air Force data files, we first produced a file of all patients treated at Air Force CONUS hospitals (over 316,000 patients). This data base was then used to produce the CONUS Hospital's report.

A data set of selected Air Force hospitals to be used in a more detailed analysis when and if needed was then created. The hospitals selected for this data set were March Composite, Malcolm Grow and Wilford Hall Air Force Hospitals. This data base, which will be called the three-hospital file, contains approximately 39,000 records.

During the creation of these data files and the subsequent processing needed to produce the desired reports, some difficulties were encountered in

handling the open-endness of the patients' length of stay. It was decided that 100 days would be the longest length of stay used in the computations; since few patients stay that long, and because of limited core size. Any patient who remained in the hospital for more than 100 days was counted as present for exactly 100 days.

A further problem developed in testing the file structures. The data base was much too large to be easily handled by a single data analysis program. Therefore, a hospital analysis system was implemented with a series of rather minor programs designed to aggregate and massage the data into report form.

While this method is somewhat more complicated operationally than a single program system, it does allow for easier program testing at each process step. The multi-phase approach also allows for a stepwise progression through the analysis.

For the CONUS file and for each hospital on the three hospital files, the implementation of this multi-phase system produced the following reports:

1) A report by beneficiary type and primary diagnosis.
2) A report by beneficiary type but independent of primary diagnosis.
3) A report by primary diagnosis and independent of beneficiary type.
4) An aggregation of all patients on the file.

In each of the above, data was stratified by age, whether the patient had a single or multiple diagnosis, or whether surgery was performed.

IMPLEMENTING A MULTI-PHASE SYSTEM

PHASE 1

After receiving the six reels of Air Force tapes, the first efforts were directed toward reducing the number of reels and making the data

file resident on the 360 system. A COBOL tape copy program was written to copy the data to two reels of OS 360 compatible tape.

PHASE 2

The two tape reels produced in Phase 1 were used as input. This program created both the CONUS hospital file and the three hospital file. The CONUS data set when created contained approximately 35,000 records which was an aggregation of over 316,000 patients. The three hospital files when created had approximately 39,000 records. There was one record for each patient treated in the selected hospitals. March AFB had approximately 7,000 records on the file; Andrews, 10,500; and Lackland, 21,500.

PHASE 3

The input to this phase of the project was the CONUS file created in Phase 2. The program generated the CONUS reports for beneficiary type and disease category and also produced a tape which totals the beneficiary type and disease category to make possible the aggregate reports.

PHASE 4

This program produced the aggregate reports for the CONUS file as well as the reports for the three hospital files.

PHASE 5

This program adapted the data in the three hospital files to the Phase 4 program. The program output is a tape of records which are identical in form to the Phase 3 output.

All population attribute codes are listed below. This list contains both the internal representation, which is always numeric, and a translation of what the code means, both generically and with respect to the Air Force coding scheme. Also included is the data saved for report purposes.

A. Beneficiary Type Attribute

Code	Translation	Card Columns Used & Values	Air Force Report Reference
1	Military Recruit	CC24-5 ≤ 23	ACN 4_86, Volume I, Part Five, AFM 300_4
		CC23 = 8	ACN 4_50, " " "
		CC22 = M	ADE EL_020, Volume IX, AFM 300_4
		CC21 = 0, 1, 2	" " "
2	Military Vietnam	CC24-5 ≤ 23	ACN 4_86, Volume I, Part Five, AFM 300_4
		CC38-9 = { ZE, VS, VN }	ADE GE_550, Volume I, AFM 300_4
3	Military (not Vietnam)	CC24-5 ≤ 23	ACN 4_86, Volume I, Part Five, AFM 300_4
4	Dependents of Active Duty	CC24 = 5	" " " "
		CC25 = 1, 2, 3, 4, 8, 9	" " " "
5	Retired	CC24 = 4 3	" " " "
		CC25 = 1, 2, . . . , 6	" " " "
6	Dependents of Retired	CC24 = 5	" " " "
		CC25 = 5, 6, 7	" " " "
7	Other	CC24 = 6	" " " "
		CC25 = 1, 2, . . . , 7	" " " "
8	Military Officers (Used only with 3 hospital studies)	CC24-5 = 23	" " " "
		CC23 + 1, 2, . . . , 6	ACN 4_50, Volume I, Part Five, AFM 300_4

B. Sex Attribute

1	Male	CC30 = A, B, C	ACN 4_49, Volume I, Part Five, AFM 300_4
2	Female	CC30 = J, K, L	" " " "

C. Age Attribute

Code	Translation	Card Columns Used & Values	Air Force Report Reference
1	Age Range	CC19,20 = 01	ADE EL_020 and ADE MA-886, Volume IX, AFM 300_4
		or	
		CC20 = D, W, M	" " " "
		or	
		CC19,20 = RR and CC56-8 = X20	" " " "
		or	
		CC19 = M, K, P, U and CC20 = 1,2,...6	" " " "
2	Age Range	CC19-20 = 02, 03, 04	" " " "
3	Age Range	CC19-20 = 05,...., 17	" " " "
4	Age Range	CC19-20 = 18, 19	" " " "
5	Age Range	CC19-20 = 20, 21	" " " "
6	Age Range	CC19-20 = 22,....,34	" " " "
7	Age Range	CC19-20 = 35,....,44	" " " "
8	Age Range	CC19-20 = 45,....,49	" " " "
9	Age Range	CC19-20 = 50,....,64	" " " "
10	Age Range	CC19-20 = 65,....,99	" " " "

D. Diagnosis Attribute

1	Single Diagnosis	CC75 = A or 0	ADE DI-005, Volume IX, AFM 300_4
2	Multiple Diagnosis	CC75 = B or 1	" " "

E. Operation Attribute

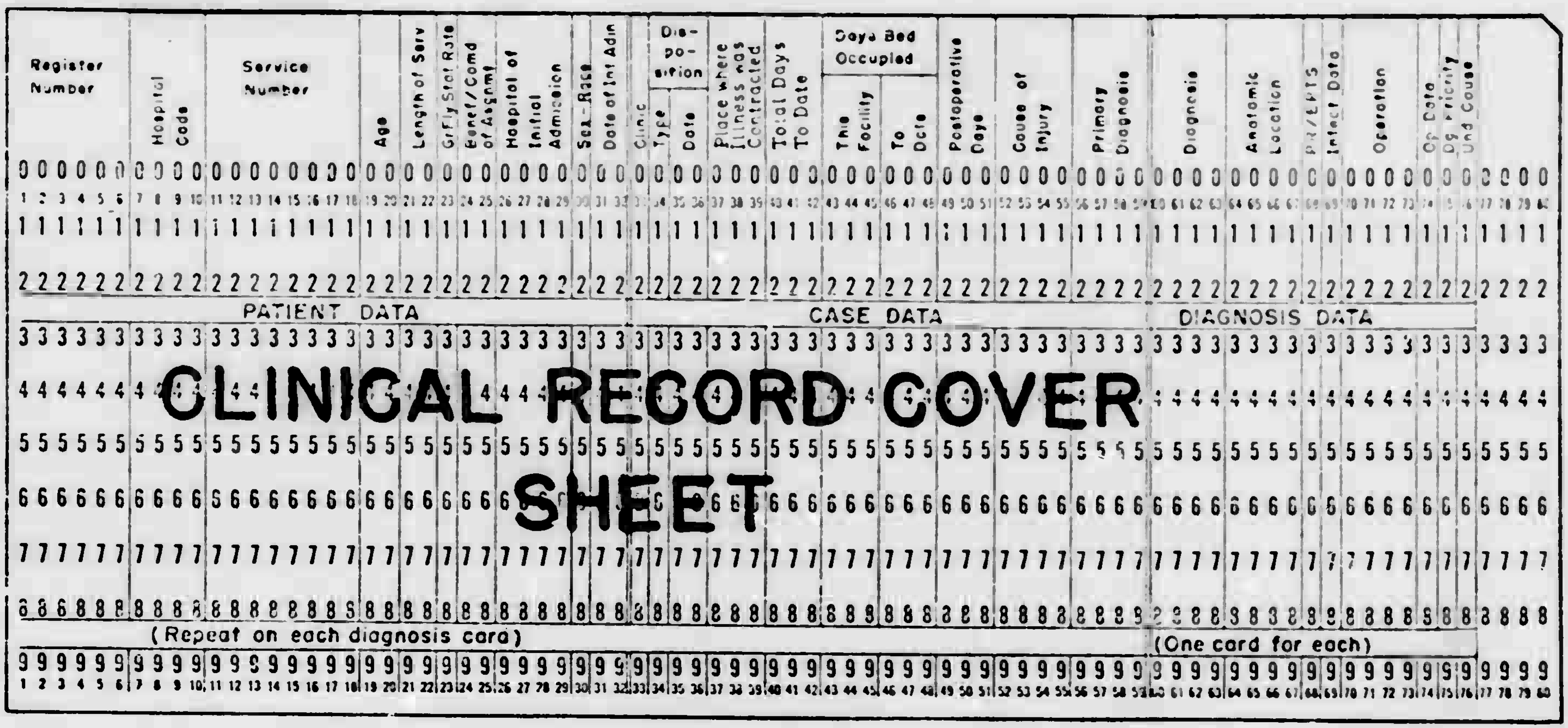
1	No Operation	CC74 = 9	ADE SU-668, Volume IX, AFM 300_4
2	Operation	Otherwise	" " "

F. Disease or Condition Attribute

Code	Standard DoD Disease and Injury Range	Generic Translation
1	0020-1349	Infective & Parasitic
2	1400-2399	Neoplasms
3	2400-2899	Allergic and Nutritional
4	2900-2990	Diseases of the Blood
5	3000-3299	Mental, and Personality Disorders
6	3300-3983	Nervous System
7	4000-4683	Circulatory System
8	4700-5279	Respiratory System
9	5300-5879	Digestive System
10	5900-6379	Genitourinary System
11	6400-6890	Deliveries
12	6900-7169	Diseases of the Skin
13	7200-7499	Diseases of the Bones
14	7500-7599	Congenital Malformations
15	7600-7760	Diseases of Early Infancy
16	7800-7959	Ill-defined Conditions
17	8000-9999	External Causes
18	x200-y299	Births and Special Admissions

Data Retained for Statistical Reports

	Type of Data	Card Columns and Values
1)	Length of Stay	CC43-5 = 001,...,999
2)	Hospital Code	
	a) March AFB	CC7-10 = 0558
	b) Andrews AFB	CC7-10 = 2151
	c) Lackland AFB	CC7-10 = 4465


Register Number
Hospital Code
Service Number
Age
Length of Serv
Gr Fly Stat Rate
Benef/Comd of Asgmt
Hospital of Initial Admission
Sex-Race
Date of Int Adm
Clinic
Dis-po-sition
Type
Date
Place where Illness was Contracted
Total Days To Date
Days Bed Occupied
This Facility
To Date
Postoperative Days
Cause of Injury
Primary Diagnosis
Diagnosis
Anatomic Location
PR/EPTS
Infect Data
Operation
Op Data
Dg Priority
Und Cause
PATIENT DATA
CASE DATA
DIAGNOSIS DATA
CLINICAL RECORD COVER SHEET
(Repeat on each diagnosis card)
(One card for each)

APPENDIX 3.1-2

AGE-SEX DISTRIBUTION OF BENEFICIARIES AUTHORIZED FOR CARE IN MILITARY HOSPITALS

SUMMARY

Tables 1 to 4 give an approximate age-sex distribution of beneficiary categories. Figures for dependents were derived by using CHAMPUS inpatient admission figures in conjunction with Household Interview Survey statistics on inpatient admissions. Those for active duty personnel were taken from the 1967 AF Biostatistics Report. Those for retirees were from OSD (OM & RA).

ASSUMPTIONS

1. The USAF Biostatistics report for 1967 gives an age-sex breakdown of military personnel that adequately represents all three services.
2. The hospital admission rate of the non-military beneficiaries is the same as the hospital admission rate of the overall U.S. population for each age-sex cohort.
3. For each category of non-military beneficiaries, the fraction of total hospital admissions under CHAMPUS within each age-sex cohort is a constant. For example, if 40 percent of the total hospital admissions of dependents of active duty personnel occurred under CHAMPUS, then 40 percent of the total hospital admissions for each age-sex cohort occurred under CHAMPUS.

SOURCES

1. USAF Biostatistics Report, 1967
2. CHAMPUS 12th Annual Report, Calendar year 1968
3. Household Interview Survey, National Center for Health Statistics, Department of Health, Education and Welfare, 1967.

METHOD

For the age breakdown of active duty personnel, Appendix Table I of the USAF Biostatistics report was used.

The age-sex distribution of non-military beneficiaries was derived as follows, for each category of non-military beneficiary:

1. For each age-sex cohort, the number of hospital admissions under CHAMPUS was divided by the admission rates of that age-sex cohort as found in Table 13 of the H.I.S. report. This result is the number of people at risk who might have used CHAMPUS, by Assumption 2.
2. The number of people at risk in each age-sex cohort was summed over the cohorts to find the total number at risk.
3. The fraction of the population each age-sex cohort makes up is the number at risk in that cohort divided by the total number at risk, since the fraction in each cohort admitted under CHAMPUS is a constant (Assumption 3).

The relevant tables in the CHAMPUS report are: Table 14-Distribution of Hospital Admissions by age and patients' relationship to sponsor for dependents of active duty personnel, CY 1968 (p. 43); Table 19- (same) for dependents of retired or deceased personnel and for retired personnel, CY 1968 (p.49).

TABLE 1

AGE DISTRIBUTION OF MALE ACTIVE DUTY MILITARY PERSONNEL [1]

Age Span	Percentage in Span	%/Year in Span
17-19	10	3.3
20-24	40	8.0
25-29	15	3.0
30-34	15	3.0
35-39	13	2.6
40-44	3.6	0.36
45-59	4.4	0.29

[1] Females form a small percentage of the armed forces.

TABLE 2

AGE-SEX DISTRIBUTION OF DEPENDENTS OF ACTIVE DUTY PERSONNEL

	Male		Female	
Age Span	Percentage in Span	%/Year in Span	Percentage in Span	%/Year in Span
0-4	18.5	3.7	12.4	2.5
5-9	7.7	1.5	7.2	1.4
10-14	3.1	0.62	13.4	2.7
15-19	1.9	0.38	20.6	4.1
20-24	*		13.3	2.7
25-34	*		2.1	0.21
35-44	*		*	
45 +	*		*	
	31		69	

* Small percentage

TABLE 3

AGE DISTRIBUTION OF MALE RETIRED PERSONNEL[1], [2], [3]

Age Span	Percentage In Span	%/Year In Span
15-34	2.1	.011
35-44	19.5	1.95
45-54	49.5	4.95
55-64	17.8	1.78
65-69	5.5	1.1
70-74	3.2	0.64
75-84 (all)	2.58	0.26

1 Female retired personnel form a small percentage of retired personnel.

2 Source: OSD, Manpower & Reserve Affairs.

3 The exact number of military retirees who are VA beneficiaries for disability compensation was not available.

TABLE 4

AGE-SEX DISTRIBUTION OF DEPENDENTS OF RETIRED AND DECEASED PERSONNEL

	Male		Female	
Age Span	Percentage in Span	%/Year in Span	Percentage in Span	%/Year in Span
0-4	4.1	0.82	3.9	0.78
5-9	6.7	1.3	5.8	1.2
10-14	7.7	1.5	6.4	1.3
15-19	11.	2.2	13.	2.6
20-24	3.2	0.64	4.1	0.82
25-34	*		3.9	0.39
35-44	*		11.	0.11
45-54	*		10.	0.10
55-64	*		5.2	0.52
65-69	*		2.1	0.42
70-74	*		1.3	0.26
75-84	*		0.6	0.06
	33		67	

* Small percentage

APPENDIX 3.1-3

DISPENSARY VISITS, OUTPATIENT VISITS, AND ADMISSIONS AT THE STUDY HOSPITALS

WOMACK ARMY HOSPITAL, FORT BRAGG, NORTH CAROLINA

CY69

Beneficiary Type	Population [1]	Dispensary Visits/Year [2,3,5]	Outpatient Visits/Year [2,3,5]	Admissions /Year [3,4]
Trainees	11,000	-	-	-
Active duty	51,534	349,503	240,655	13,712
Dependents of active duty	82,466	-	288,965	5,884
Retired	6,000	-	13,358	581
Dependents of ret. & dec.	9,000	-	9,750	838
Others	4,236	-	3,455	43

(1) DoD Data Pack.
(2) Physicals and immunizations are excluded.
(3) All figures are for December 1968 through November 1969.
(4) DA 2789 (Morbidity Report), IHRA and transfers in are excluded.
(5) DD 444 (Outpatient Report). Outpatient visits determined by: Army Active Duty clinic visits (line 2b) -- dispensary visits (line 8b) + USAF and Navy personnel visits (line 3b). Recruits are included in the figures for dispensary visits, outpatient visits, and admission of active duty personnel.

OAKLAND NAVAL HOSPITAL, CALIFORNIA

FY69

Beneficiary Type	Population [1]	Dispensary Visits/Year [2]	Outpatient Visits/Year [3]	Admissions /Year [4]
Trainees	0	0	0	0
Active duty	79,082	-	49,467	6,346
Dependents of active duty	159,360	-	98,488	4,191
Retired	39,125	-	31,121	1,444
Dependents of ret. & dec.	86,574	-	66,248	2,095
Others	31,483	-	4,580	153

1. DoD Data Pack.
2. Reports from dispensaries were not available.
3. NAVMED 1454 (Medical Services Report) FY69.
4. "Commanding Officers Fact Book," CY68.

JACKSONVILLE NAVAL HOSPITAL, FLORIDA

CY69

Beneficiary Type	Population[1]	Dispensary Visits/Year[2,3]	Outpatient Visits/Year[2,4]	Admissions /Year[5]
Trainees	0	0	0	0
Active duty	21,205	77,288	27,150	2,934
Dependents of active duty	88,625	-	180,725	3,412
Retired	24,659	-	23,634	746
Dependents of ret. & dec.	61,637	-	44,875	1,073
Others	2,682	-	3,211	317

1. DoD Data Pack, updated during data collection.
2. Excluding immunizations and physicals.
3. Dispensary visit figures for active duty personnel include visits at U.S. Naval Air Station (63,818) and Mayport (13,470).
4. Including non-military beneficiaries treated at Mayport dispensary (dependents of active duty personnel, 5,864; retired, 2,516; dependents of retired or deceased personnel, 5,787, and others, 231).
5. The admission figures were found by distributing total admissions for CY69 according to the percentages for CY68. Transfers were excluded.

DEWITT ARMY HOSPITAL, FORT BELVOIR, VIRGINIA

CY69

Beneficiary Type	Population [2]	Dispensary Visits/Year [2,4,5]	Outpatient Visits/Year [2,4,5]	Admissions /Year [3]
Trainees	0	0	0	0
Active duty	35,000	231,532	166,336	2,674
Dependents of active duty	105,000	-	277,760	4,843
Retired	36,000	-	18,438	658
Dependents of ret. & dec.	72,000	-	45,908	1,212
Others	6,000	-	17,067	139

1. DoD Data Pack.
2. Excluding immunizations and physicals.
3. DA 2789 Morbidity Report. Transfers and IRHA were excluded. The October and December reports were not available; figures adjusted to estimate 12-month total.
4. Visits at the Vint Hill Farms Dispensary were estimated by adjusting the figures from DAHRD Form 29 for October and November, 1969, to a 12-month period. The estimates are: active duty personnel, 24,456; dependents of active duty personnel, 19,020; retired personnel, 8,244; dependents of retired and deceased personnel, 8,856; al. others, 192.
5. The figures for dispensary visits are taken from DAHRD Form 29, which includes the North Post Dispensary. The figures for active duty visits estimated at the Vint Hill Farms Dispensary were added (see 4).
6. The figures for outpatient visits are taken from DD 444 for January to November, 1969, adjusted for a 12-month estimate. Visits by non-military beneficiaries at Vint Hill Farms Dispensary (see 4) were added to the totals.

MALCOLM GROW AIR FORCE HOSPITAL
ANDREWS AIR FORCE BASE, D.C.
FY69

Beneficiary Type	Population[1]	Dispensary Visits/Year[2,4]	Outpatient Visits/Year[2,4]	Admissions /Year[3]
Trainees	0	0	0	0
Active duty	20,781	66,504	94,225	1,878
Dependents of active duty	51,592	-	220,423	4,074
Retired	1,974	-	16,746	577
Dependents of ret. & dec.	3,737	-	34,482	928
Others	581	-	8,113	80

1. DoD Data Pack.
2. Excluding immunization and physicals.
3. AF235 (Report of Patients) for FY69. Transfers and IRHA are excluded.
4. Including visits at Bolling Air Force Base and Pentagon Dispensary, derived by subtracting outpatient visits to Malcolm Grow Clinic from clinic visits in the overall base report (AF235, part II, line 22).

BEAUFORT NAVAL HOSPITAL, BEAUFORT, SOUTH CAROLINA

CY69

Beneficiary Type	Population[1]	Dispensary Visits/Year[2,4,5]	Outpatient Vists/Year[2,5,6,8]	Admissions /Year[3,7]
Trainees	10,000	165,942	-	1,094
Active duty	7,125	58,961	28,706	1,051
Dependents of active duty	12,683	-	83,131	1,685
Retired	500	-	3,227	122
Dependents of ret. & dec.	750	-	4,250	139
Others	1,176	-	1,237	18

1. DoD Data Pack, updated during data collection at Beaufort.
2. Immunizations and physicals are excluded.
3. BUMED-414-DAR-7, excluding transfers and IRHA.
4. Visits to the Parris Island Dispensary were taken from NAVMED 1454 for the period January 1969 to August 1969, and adjusted to a 12-month total. The visits thus estimated are: recruits, 165,942; active duty personnel, 28,793; dependents of active duty personnel, 941; retired personnel, 51; dependents of retired or deceased personnel, 2; others, 594. Visits from the Marine Corps Air Station were estimated for the same period from NAVMED 1454 at 30,168 visits by active duty personnel, others 0.
5. Figures for dispensary visits by active duty personnel include Parris Island (28,793) and the Marine Corps Air Station (30,168).
6. Including visits at the Parris Island Dispensary by the non-military beneficiaries (see 4).
7. Of a sample of 102 inpatient medical records of active duty personnel at Beaufort, 52 were recruits. 51 percent of the 2,146 admissions of active duty personnel are estimated to be recruits.
8. Recruits' outpatient visits are included in those of active duty personnel.

WALSON ARMY HOSPITAL, FT. DIX, NEW JERSEY

FY69

Beneficiary Type	Population [1]	Dispensary Visits/Year [2,5]	Outpatient Visits/Year [2,4,5]	Admissions /Year [3]
Trainees	9,000	4	-	16,525
Active duty	26,000	252,381	261,230	8,273
Dependents of active duty	68,000	-	60,065	4,796
Retired	5,000	-	6,720	921
Dependents of ret. & dec.	2,500	-	5,812	1,026
Others	4,500	-	11,178	170

1. DoD Data Pack, updated during data collection.
2. Immunizations and physicals excluded.
3. Taken from a random sampling of 706 admission sheets at Walson Army Hospital for FY69 with the distribution applied to total admissions (31,761) for that period.
4. Figure for dispensary visits of active duty personnel includes recruits.
5. DD 444 for FY69 these include dispensary visits and visits to McGuire AFB dispensary taken from AF235 for FY69. Included in outpatient visits are dispensary visits by non-military beneficiaries: dependents of active duty personnel, 3,409; retired personnel, 275; dependents of retired or deceased personnel, 45; and others, 2,018.

WILFORD HALL COMPOSITE MEDICAL FACILITY
LACKLAND AIR FORCE BASE, TEXAS

FY69

Beneficiary Type	Population[1]	Dispensary Visits/Year[2,3,5]	Outpatient Visits/Year[2,3,5]	Admissions /Year[4]
Trainees	11,000	-	-	1,982
Active duty	23,479	122,590	373,238	4,387
Dependents of active duty	52,341	-	364,198	8,819
Retired	11,093	-	43,461	1,815
Dependents of ret. & dec.	22,085	-	54,563	2,385
Others	1,877	-	95,192	398

1. DoD data pack, including Lackland, Kelly, Brooks, and Randolph AFB. Recruits estimated during data collection.
2. Exclude immunizations and physicals.
3. USAF Outpatient Report RCS-IR (AF) M219 for August 1969, for Lackland, Kelly, Brooks, and Randolph AFB. Recruits are included with active duty personnel.
4. Medical record summary sheets. Transfers are included; IRHA excluded.
5. Including dispensary visits by non-military beneficiaries: dependents of active duty personnel, 105,985; retired personnel, 7,542; dependents of retired or deceased personnel, 10,437, and others, 83,538.

MARCH COMPOSITE MEDICAL FACILITY
MARCH AIR FORCE BASE, CALIFORNIA
FY69

Beneficiary Type	Population [1]	Dispensary Visits/Year [2]	Outpatient Visits/Year [2]	Admissions /Year [3]
Trainees	0	0	0	0
Active duty	13,023	39,259	54,393	2,365
Dependents of active duty	21,139	-	110,213	2,406
Retired	25,643	-	21,074	675
Dependents of ret. & dec.	60,685	-	43,587	1,060
Others	4,005	-	736	43

1. DoD Data Pack for March and Norton Air Force Bases.
2. USAF Outpatient Report RCS-IR(AF)-M219 for August 1969 (full year figures). Included in outpatient visits are dispensary visits by non-military beneficiaries: dependents of active duty personnel, 59,166, retired personnel, 8,776; dependents of retired or deceased personnel, 17,314; and others, 1,388.
3. AF234 for FY1969 for March and Norton Air Force Base, excluding transfers and IRHA.

APPENDIX 3.1-4

POTENTIAL ADMISSIONS FROM NON-MILITARY BENEFICIARIES

SUMMARY

Admission rates for non-military beneficiaries were derived using statistics on hospital discharges from the Household Interview Survey together with age-sex breakdowns of the beneficiary categories. The derived admission rates are shown in Table 1.

REFERENCES

(1) "Age-sex Distribution of Beneficiaries Authorized for Care in Military Hospitals," Systems Analyses, DAC15-69-C-0345.

(2) "Number of Discharges from Short-Stay Hospitals -- 1967," Table 13, Household Interview Survey, Series 10, National Center for Health Statistics, Public Health Service, Dept. of Health, Education and Welfare.

METHOD

Table 2 shows the relevant statistics from the Household Interview Survey (Reference 2). Tables 3, 4, and 5 show the age-sex breakdowns for each category of non-military beneficiary. For the retired and dependents of retired and deceased, the following procedure was used: the fraction of each age-sex cohort of the distribution is multiplied by the admission rate for that cohort. These fractional rates are summed to arrive at a weighted average.

For dependents of active duty the procedure differs in one respect. Since a larger proportion of the admissions of females under CHAMPUS in the 14 to 17 year age group were children of active duty personnel (CHAMPUS Twelfth) Annual Report), the admission rate of females in the 17 to 24 year age group has been used for females 14 to 17 years of age.

TABLE 1

BENEFICIARY CATEGORY	ADMISSION RATE
Dependents of Active Duty Personnel	144
Retired Personnel	140
Dependents of Retired or Deceased Personnel	144

TABLE 2

Number of Discharges per 1000 persons per year, by age and sex: United States, 1967 [1]

AGE	MALE	FEMALE
0-16	72	57
17-24	78	236
25-34	75	230
35-44	101	153
45-64	137	146
65 +	214	183

[1] Household Interview Survey, 1967, Reference 1

TABLE 3

Age-sex Distribution of Dependents of Active Duty Personnel

in H. I. S. Age Ranges

Age	% (Male)	% (Female)
0-16	29.9	41.2
17-24	1.1	25.6
25-34	*	2.1
35-44	*	*
45-64	*	*
65 +	*	*

* Small percentage

TABLE 4

Age-sex Distribution of Male Retired Personnel

in H. I. S. Age Ranges

Age	% (Male)
0-16	0
17-24	.088
25-34	2.01
35-44	19.5
45-64	67.30
65 +	11.28

TABLE 5

Age-sex Distribution of Dependents of Retired or Deceased Personnel

in H. I. S. Age Ranges

Age	% (Male)	% (Female)
0-16	20.9	18.7
17-24	12.0	14.3
25-34	*	3.9
35-44	*	11.0
45-64	*	15.2
65 +	*	4.0

*Small percentage

APPENDIX 3.1-5

EXPECTED BREAKDOWN OF SPECIALTY CLINIC USAGE BY NON-MILITARY BENEFICIARY TYPE AS DERIVED FROM H.I.P. STATISTICS

SUMMARY

To supplement the data collection from military hospitals, expected specialty clinic usage by each category of non-military beneficiary was derived using statistics from the Health Insurance Plan of Greater New York (for 1965) in conjunction with the estimated age-sex breakdown of the non-military beneficiaries.

REFERENCES

(1) "Age-Sex Distribution of Beneficiaries Authorized for Care in Military Hospitals", Systems Analysis, DAHC15 69 C 0354.

(2) "H.I.P. Statistical Report," Health Insurance Plan of Greater New York, 1965.

METHOD

In the "H.I.P. Statistical Report," Table 8 utilization rates by age and physician specialty are shown for CY1965, based on a 10 percent sample of the H.I.P. population (677,923). These physician utilization rates included both office visits and hospital visits. Hospital visits were approximately 10 percent of the total physician services.

The distributions of BLHC beneficiaries were used to find the number of people in each of the H.I.P. age ranges as shown in Tables 3, 4 and 5. These distributions by age of each category of non-military beneficiaries were multiplied by the number of specialty services in each age range for each physician specialty to arrive at the number of specialty services expected for each category of non-military beneficiary.

For expected usage of obstetricians and gynecologists only the female portion was taken of dependents of active duty personnel and dependents of retired or deceased personnel. The retired were assumed to be all male.

RESULTS

Table 1 shows expected physician services per person in each non-military beneficiary category for each physician specialty, and the percentage of services given all persons of a given category by specialty. In this table, "Surgery" includes Otolaryngology, Urology, and general surgery; "Medicine" includes Allergy, Dermatology, Internal Medicine, and general medicine.

Table 2 shows physician specialty services by age of patient and expected services per year for each beneficiary category. In this table, surgery and medicine are shown in their component specialties.

DISCUSSION

Several assumptions are embodied in this comparison; the major ones are:

1. For each age range and beneficiary category, the distribution of males and females is the same as the H.I.P. population. Comparison for each beneficiary category (Reference 1) shows the greatest disparity is for elderly dependents of retired or deceased personnel, who are all female.
2. The potential demands of the non-military beneficiaries for the services of specialists is the same as that of the H.I.P. population. Since most specialist services, both in civilian and military practice, tend to be by referral, the differences are not felt to be crippling.

TABLE 1—EXPECTED SPECIALTY PHYSICIAN SERVICES BY SPECIALTY AND BY CATEGORY OF NON-MILITARY BENEFICIARY

	ORTHO	PEDS	OB-GYN	OPTH	SURG	MED	GEN MED	OTHER	TOTAL
Dep. AD	.144	1.28	.238	.109	.285	1.848	(1.11)	.026	3.93
%	3.66	32.56	6.05	2.8	7.25	17.0	(36.6)	0.66	99.98
Ret.	.189	0	0	.251	.654	3.54	(2.82)	.065	4.70
%	4.02			5.31	13.9	75.3	(60.0)	1.38	99.94
Dep. Ret.	.151	.714	.243	.142	.387	2.39	(1.89)	.038	4.07
%	3.71	17.56	5.97	3.[illegible]	9.52	58.8	(46.5)	.93	99.98

Note: Each entry in the table gives the expected number of services per year and the percentage of services given a member of the beneficiary category by the specialty.

TABLE 2 — PHYSICIAN UTILIZATION BY PHYSICIAN SPECIALTY AND BY AGE OF PATIENT[1]

Age Span	ORTHO	PEDS	OB-GYN	OPTH	GEN SURG	OTOLAR	PRO	INTERNIST	ALLERG	GEN MED	DERM	OTH.
0–14	.157[2]	2.069	.031	.195	.100	.123	.026	.031	.211	[illegible]	[illegible]	.019
15–44	.123	0	.633	.099	.219	.087	.038	.118	.240	[illegible]	.128	.037
45–64	.195	0	.205	.231	.393	.118	.109	.111	.189	[illegible]	.119	.060
65+	.257	0	.107	.510	.501	.201	.110	.755	.132	[illegible]	.171	.126
Dep. AD	.111	1.28	.238	.109	.145	.109	.031	.064	.236	1.13	.098	.026
Ret.	.189	0	0	.251	.373	.113	.138	.105	.189	2.82	.127	.065
Dep Ret	.1597	.711	.213	.112	.215	.113	.060	.158	.233	1.89	.112	.038

1 Adapted from H.I.P. statistical report, 1965. Radiologist services were not included.

2 Each entry in the expected number of services per year given a person of the indicated age range by the specialty.

Table 3 — Age-sex distribution of dependents of active duty personnel in H. I. P. age ranges

Age Span	% (both sexes)	% (male)	% (female)
0-14	62	29.3	33.
15-44	38	1.9	36.
45-64	*	*	*
65+	*	*	*

* Negligible Percentage

Table 4 — Age-sex distribution of retired personnel in H. I. P. age ranges

Age Span	% (male)[1]
15-44	17.9
45-64	66.6
65+	14.3

[1] Females are a negligible percentage of retired personnel.

Table 5 — Age-sex distribution of dependents of retired or deceased personnel in H. I. P. age ranges

Age span	% (both sexes)	% (male)	% (female)
0-14	34.5	18.5	16.1
15-44	46.2	14.2	32.0
45-64	15.2	*	15.2
65+	4.0	*	4.0

* Negligible Percentage

APPENDIX 3.1-6

ANALYSIS OF BEAUFORT AND JACKSONVILLE NAVAL HOSPITALS

PATIENT CARE REQUIREMENTS

The initial phase of this project required a search of the hospitals' inpatient medical records file to obtain a random sampling of patients. A sample of approximately 5 percent of the annual admissions was obtained from the Jacksonville Naval Hospital and the Beaufort Naval Hospital. The search was formalized to capture information about the type of patient entering the hospital, the reason for entering, length of stay, statistics on the patient's progression through the various care levels, and the number and type of tests administered to the patient.

This data was then edited to gain a degree of uniformity. This included coding a consistent Disease or Condition on each record, treating the military recruits in a consistent manner, and rejecting insufficient information which did not fit into the coding scheme. Data was then keypunched. Tables 1 and 2 give information about the card format and the coding system used in punching the card deck.

The second project phase was the implementation of a computer program to analyze the collected data.

The first report analyzes the distribution of bed days in the hospital by care level. This report is produced for each beneficiary type and for each of the 18 general disease categories; sub-breakdowns are age and sex.

The second report is also produced by disease category and beneficiary type. Within this code the patients are aggregated by age, whether surgery was performed and whether a single or multiple diagnosis was determined. The output contains the aggregation of the patients by the population factors above. It also contains length of stay statistics and a percentile distribution of patients by their length of stay.

The third report uses the same population cohorts as Report 2. Here we aggregate the number of laboratory tests performed on the patients, including Hematology, Urology, and Radiology tests. The output consists of the number of patients, the number of each laboratory test, the average number per patient, and variances for each item.

Report 4 gives a detailed breakdown of patients by day of stay beneficiary type and disease category. The patients that underwent surgery were separated from those who did not. Each day of stay is displayed together with the number of patients that are present in the hospital on that day. For those patients who stayed more than 51 days, we aggregated the number of days over 50 and stored it in day number 51.

For each day of stay the distribution of the patient days within each level of care is printed, as well as the number of laboratory tests with its associated statistics.

Card 1 - Description

Codes for header and data items for Medical Records

Item	Card Column	Header Information	Char
1	1	Hospital	1A
2	2-4	Unique Person Identifier	3D
3	5-6	Card #	2D
4	7	Point of Origin (how got to hospital)	1A
5	8	Disposition	1A
6	9-14	Date Admitted	6D
7	15-20	Date of disposition	6D
8	21-22	Age	2D
9	23	Sex	1A
10	24-25	Beneficiary type (type of patient)	2A
11	26	Rank (if any) Officer Ø, Enlisted E	1A
12	27-29	Length of Stay	3D
13	30-33	Primary Diagnosis (discharge)	4A
14	34	Number of Secondary Diagnosis	1D
15	35-38	Secondary Diagnosis #1	4A
16	39-42	Secondary Diagnosis #2	4A
17	43-46	Secondary Diagnosis #3	4A
18	47-50	Secondary Diagnosis #4	4A

Card 1 - Codes

Item	Column	Code	Explanation
1	1	J or B	J=Jacksonville, B=Beaufort
2	2-4	001-999	in sequence for each hospital
3	5-6	01-99	card # for each medical record
4	7	T=Transferred In	any other hospital, Vietnam
		D=from dispensary	
		S=Self-referred	dependents and retired
5	8	D=Discharged	from hospital - after some period no notation
		T=Transferred out	to another hospital
		X=Death	
		R=Retired from Service	
		U=Unauthorized discharge	AWOL
6	9-14	YYMMDD	2-digit year, 2-digit month, 2-digit day
7	15-20	Same	Ibid.

Card 1 - Codes (cont'd)

Item	Column	Code	Explanation
8	21-22	NN	Age
9	23	M=Male F=Female	Sex
10	24-25	MV=Military Vietnam MR=Recruit MN=blank or Navy USA MM=USMC MA=Army USA MF=USAF MC=Marine Corp DM=Dependnet of active duty military RT=Retired DR=Dependent of Retired OT=Other	
11	26	Ø=Officer E=Enlisted ø=Other	
12	27-29	NNN=length of stay	
13	30-33	AAAA=primary diagnosis	
14	34	N=# of secondary diagnoses	
15-18	35-38	AAAA=Diagnosis; if none, = blank	

Card 2 - Description
Data Record

Item	Information	Char
1	Day of stay-start	2D
2	Day of stay-end	2D
3	Level of care	1A
4	Lab-Hemo	1D
5	Lab-Urology	1D
6	Lab-Misc	1D
7	Surgery-Major	1D
8	Surgery-Minor	1D
9	Radiology-Major	1D
10	Radiology-Routine	1D

Card 2 - Codes

Item	Column	Code	Explanation
1	1-2	NN	Start day for this record
2	3-4	NN	End day for this record
3	5	C	Cornary care unit, labeled CCU
		I	Intensive care unit, labeled ICU
		D	Delivery
		H	Heavy care, labeled HVY
		M	Moderate care, labeled MOD
		L	Light care, labeled LGT
		A	Authorized leave
		U	Unauthorized leave AWOL
		N	Croupette, MIST or nursery, labeled NVR
4	6	N	# Hemoglobin laboratory tests
5	7	N	# Urology laboratory tests
6	8	N	# Miscellaneous laboratory tests
7	9	N	# Major surgery this day
8	10	N	# Minor surgery this day
9	11	N	# Major radiology tests
10	12	N	# Routine radiology tests

APPENDIX 3.2-1

McKEE-BERGER-MANSUETO COST ANALYSIS

The data presented for the test configuration of the "New Generation" of Military Hospitals (NGMH) is representative of the general cost profile of the NGMH system design.

Cost Analysis of NGMH (T_0)

The initial task of the analysis was to determine T_0 costs of the NGMH system design for a range of alternative structural, architectural and mechanical solutions. These solutions were applied to a typical configuration (570 beds, 507,000 s/f) in order to quantify the various cost relationships involved. From these data a "test" solution was selected to permit comparison with "conventional" hospital cost data. The building systems selected are not complete but are representative of a range of probable solutions in terms of both cost and method of construction.

To accomplish this task, costs were analyzed by the following building system categories:

1.0 Foundation
2.0 Superstructure
3.0 Exterior Wall
4.0 Interior Finish
5.0 Roof
6.0 Casework
7.0 Plumbing
8.0 Heating, Ventilating, and Air Conditioning
9.0 Electrical
10.0 Elevators

Where appropriate, alternatives were analyzed within a given category, including seven alternatives under the Structural category, four under Exterior Wall, three under Interior Finishes and three under HVAC. Costs were also

analyzed by level and functional area within each level.

In some instances, however, building system costs and the costs of certain elements could not be appropriately distributed among levels and areas. These exceptions include the Foundation, Roof and Elevator systems; circulation areas; primary and secondary nodes; and the distribution of Exterior Wall costs to interior areas.

The costs of the Foundation, Roof and Elevators systems have been treated as non-distributable "constants", which are added in the summary analysis of the total cost of the NGMH system. Also, because the NGMH test configuration was assumed to have a remote energy supply*, the cost of certain mechanical and electrical equipment (boilers, chillers and towers) have been treated as constants.

This detailed analysis resulted in the matrix which follows. It should be noted that the total cost of a given building system for the four levels or for all areas within a level is not a simple average. The square feet of space assumed for each level and area varies and is reflected in the total cost.

*This assumption was necessary to permit subsequent cost comparisons with conventional hospitals to be made on a uniform basis.

NGMH To COSTS BY LEVEL, AREA AND BUILDING SYSTEM
(DOLLARS/SF)

LEVEL: AMBULATORY

BUILDING SYSTEM / AREA	Pharmacy	OB-GYN	ORTHO	PEDIATRIC CLINIC	SURGICAL CLINIC	WALK-IN CLINIC		
1.0 Foundations	-	-	-	-	-	-		
2.0 Super Structure								
2.1 Steel frame, concrete fireproofing and slabs (US Steel Scheme)	7.75	7.75	7.75	7.75	7.75	7.75		
2.2 Steel frame, concrete fireproofing and slabs (Bethlehem Scheme A)	9.16	9.16	9.16	9.16	9.16	9.16		
2.3 Steel frame, concrete fireproofing, and slabs (Bethlehem Scheme B)	8.56	8.56	8.56	8.56	8.56	8.56		
2.4 Steel frame, concrete fireproofing, and slabs (Bethlehem Scheme C)	6.18	6.18	6.18	6.18	6.18	6.18		
2.5 Reinforced concrete slabs, beams columns	8.30	8.30	8.30	8.30	8.30	8.30		
2.6 Metal deck & Concrete slab (Inpatient level only)	-	-	-	-	-	-		
2.7 Precast Concrete (Inpatient level only)	-	-	-	-	-	-		
3.0 Exterior Wall								
3.1 Face Brick, Masonry Back-up (Cavity)	4.03	4.03	4.03	4.03	4.03	4.03		
3.2 Face Brick, Masonry Back-up (solid)	4.45	4.45	4.45	4.45	4.45	4.45		
3.3 Stucco Facing, Blockwall	3.73	3.73	3.73	3.73	3.73	3.73		
3.4 Precast Concrete Panels	5.24	5.24	5.24	5.24	5.24	5.24		
3.5 Glass & Metal Panels	5.38	5.38	5.38	5.38	5.38	5.38		

NGMH T_O COSTS BY LEVEL, AREA AND BUILDING SYSTEM
(DOLLARS/SF)

LEVEL: AMBULATORY

BUILDING SYSTEM / AREA	PHARMACY	OB-GYN	ORTHO	PEDIATRIC CLINIC	SURGICAL CLINIC	WALK-IN CLINIC			
4.0 Interior Finish									
4.1 Austere	7.52	11.77	11.77	11.34	12.62	11.77			
4.2 Average	8.85	13.85	13.85	13.35	14.85	13.85			
4.3 Generous	10.52	16.46	16.46	15.87	17.65	16.46			
5.0 Roof System	-	-	-	-	-	-			
6.0 Casework	6.00	2.50	2.50	1.70	2.50	1.00			
7.0 Plumbing	.91	8.63	1.80	2.25	12.06	5.22			
8.0 Heating, Ventilating and Air Conditioning									
8.1 All Air/ Induction	9.40	11.51	10.46	10.46	17.33	10.46			
8.2 All Air/ Fan Coil	9.31	11.40	10.36	10.36	17.17	10.36			
8.3 All Air/ Incremental	8.87	10.86	9.87	9.87	16.35	9.87			
9.0 Electrical	4.81	5.77	5.77	5.77	7.70	5.77			
10.0 Elevators	-	-	-	-	-	-			

NGMH T_0 COSTS BY LEVEL, AREA AND BUILDING SYSTEM
(DOLLARS/SF)

LEVEL: AMBULATORY

BUILDING SYSTEM / AREA	MED. SPEC. CLINIC	RADIOLOGY	CLINIC LABS	OPD & MED.	EMERGENCY	WELFARE & REC.		
1.0 Foundations	-	-	-	-	-	-		
2.0 Super Structure								
2.1 Steel frame, concrete fireproofing and slabs (US Steel Scheme)	7.75	7.75	7.75	7.75	7.75	7.75		
2.2 Steel frame, concrete fireproofing and slabs (Bethlehem Scheme A)	9.16	9.16	9.16	9.16	9.16	9.16		
2.3 Steel frame, concrete fireproofing, and slabs (Bethlehem Scheme B)	8.56	8.56	8.56	8.56	8.56	8.56		
2.4 Steel frame, concrete fireproofing, and slabs (Bethlehem Scheme C)	6.18	6.18	6.18	6.18	6.18	6.18		
2.5 Reinforced concrete slabs, beams columns	8.30	8.30	8.30	8.30	8.30	8.30		
2.6 Metal deck & Concrete slab (Inpatient level only)	-	-	-	-	-	-		
2.7 Precast Concrete (Inpatient level only)	-	-	-	-	-	-		
3.0 Exterior Wall								
3.1 Face Brick, Masonry Back-up (Cavity)	4.03	4.03	4.03	4.03	4.03	4.03		
3.2 Face Brick, Masonry Back-up (solid)	4.45	4.45	4.45	4.45	4.45	4.45		
3.3 Stucco Facing, Blockwall	3.73	3.73	3.73	3.73	3.73	3.73		
3.4 Precast Concrete Panels	5.24	5.24	5.24	5.24	5.24	5.24		
3.5 Glass & Metal Panels	5.38	5.38	5.38	5.38	5.38	5.38		

NGMH T_O COSTS BY LEVEL, AREA AND BUILDING SYSTEM
(DOLLARS/SF)

LEVEL: AMBULATORY

BUILDING SYSTEM / AREA	MED.SPEC. CLINIC	RADIOLOGY	CLINIC LABS	OPD & MED.	EMERGENCY	WELFARE & REC.			
4.0 Interior Finish									
4.1 Austere	11.77	13.30	11.77	11.51	8.97	8.97			
4.2 Average	13.85	15.65	13.85	13.55	10.56	10.56			
4.3 Generous	16.40	18.60	16.40	16.11	12.55	12.55			
5.0 Roof System	-	-	-	-	-	-			
6.0 Casework	2.50	3.50	2.80	2.50	1.50	1.50			
7.0 Plumbing	3.00	1.55	7.10	.47	8.42	2.81			
8.0 Heating, Ventilating and Air Conditioning									
8.1 All Air/ Induction	9.40	11.51	10.46	9.40	9.40	9.40			
8.2 All Air/ Fan Coil	9.31	11.40	10.36	9.31	9.31	9.31			
8.3 All Air/ Incremental	8.87	10.86	9.87	8.87	8.87	8.87			
9.0 Electrical	5.77	3.85	5.77	3.85	4.81	3.85			
10.0 Elevators	-	-	-	-	-	-			

NGMH T_0 COSTS BY LEVEL, AREA AND BUILDING SYSTEM
(DOLLARS/SF)

LEVEL: AMBULATORY

BUILDING SYSTEM / AREA	DENTAL CLINIC	ADMIN.	MAJ. CIRC.	PRIMARY NODES	SECONDARY NODES	TOTAL COST		
1.0 Foundations	-	-	-	-	-	-		
2.0 Super Structure								
2.1 Steel frame, concrete fireproofing and slabs (US Steel Scheme)	7.75	7.75	7.75	9.55	9.55	7.87*		
2.2 Steel frame, concrete fireproofing and slabs (Bethlehem Scheme A)	9.16	9.16	9.16	11.29	11.29	9.30		
2.3 Steel frame, concrete fireproofing, and slabs (Bethlehem Scheme B)	8.56	8.56	8.56	10.55	10.55	8.70		
2.4 Steel frame, concrete fireproofing, and slabs (Bethlehem Scheme C)	6.18	6.18	6.18	7.61	7.61	6.27		
2.5 Reinforced concrete slabs, beams columns	8.30	8.30	8.30	10.22	10.22	8.43		
2.6 Metal deck & Concrete slab (Inpatient level only)	-	-	-	-	-	-		
2.7 Precast Concrete (Inpatient level only)	-	-	-	-	-	-		
3.0 Exterior Wall								
3.1 Face Brick, Masonry Back-up (Cavity)	4.03	4.03	-	-	-	2.95		
3.2 Face Brick, Masonry Back-up (solid)	4.45	4.45	-	-	-	3.26*		
3.3 Stucco Facing, Blockwall	3.73	3.73	-	-	-	2.73		
3.4 Precast Concrete Panels	5.24	5.24	-	-	-	3.84		
3.5 Glass & Metal Panels	5.38	5.38	-	-	-	3.94		

NGMH T_o COSTS BY LEVEL, AREA AND BUILDING SYSTEM
(DOLLARS/SF)

LEVEL: AMBULATORY

BUILDING SYSTEM / AREA	DENTAL CLINIC	ADMIN.	MAJ. CIRC.	PRIMARY NODES	SECONDARY NODES	TOTAL COST			
4.0 Interior Finish									
4.1 Austere	9.64	8.97	9.18	21.24	21.24	11.08			
4.2 Average	11.35	10.56	10.80	25.00	25.00	13.04*			
4.3 Generous	13.49	12.55	12.83	29.70	29.70	15.50			
5.0 Roof System	-	-	-	-	-	-			
6.0 Casework	4.50	1.00	-	-	-	1.90*			
7.0 Plumbing	3.50	3.28	1.00	-	-	3.15*			
8.0 Heating, Ventilating and Air Conditioning									
8.1 All Air/ Induction	10.46	9.40	9.40	-	-	9.74			
8.2 All Air/ Fan Coil	10.36	9.31	9.31	-	-	9.65			
8.3 All Air/ Incremental	9.87	8.87	8.87	-	-	9.19*			
9.0 Electrical	4.81	3.85	4.81	1.92	1.92	4.86*			
10.0 Elevators	-	-	-	-	-	-			

*Costs of test configuration

NGMH T_O

COSTS BY LEVEL, AREA AND BUILDING SYSTEM
(DOLLARS/SF)

LEVEL: MEDICAL/ ADMINISTRATIVE

BUILDING SYSTEM / AREA	SURGICAL SUITE	RECOVERY AREA	ICU/CCU	LABOR AND DELIVERY	NURSERY & OB UNIT	TEACHING	UNDEVELOPED SURGICAL	OPTHAL CLINIC
1.0 Foundations	-	-	-	-	-	-	-	-
2.0 Super Structure								
2.1 Steel frame, concrete fireproofing and slabs (US Steel Scheme)	8.18	8.18	8.18	8.18	8.18	8.18	8.18	8.18
2.2 Steel frame, concrete fireproofing and slabs (Bethlehem Scheme A)	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75
2.3 Steel frame, concrete fireproofing, and slabs (Bethlehem Scheme B)	9.46	9.46	9.46	9.46	9.46	9.46	9.46	9.46
2.4 Steel frame, concrete fireproofing, and slabs (Bethlehem Scheme C)	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21
2.5 Reinforced concrete slabs, beams columns	8.85	8.85	8.85	8.85	8.85	8.85	8.85	8.85
2.6 Metal deck & Concrete slab (Inpatient level only)	-	-	-	-	-	-	-	-
2.7 Precast Concrete (Inpatient level only)	-	-	-	-	-	-	-	-
3.0 Exterior Wall								
3.1 Face Brick, Masonry Back-up (Cavit	6.02	6.02	6.02	6.02	-	-	-	-
3.2 Face Brick, Masonry Back-up (solid)	6.43	6.43	6.43	6.43	6.43	6.43	6.43	6.43
3.3 Stucco Facing, Blockwall	5.47	5.47	5.47	5.47	-	-	-	-
3.4 Precast Concrete Panels	7.56	7.56	7.56	7.56	-	-	-	-
3.5 Glass & Metal Panels	7.79	7.79	7.79	7.79	-	-	-	-

NGMH T_O COSTS BY LEVEL, AREA AND BUILDING SYSTEM (DOLLARS/SF)

LEVEL: MEDICAL/ ADMINISTRATIVE

BUILDING SYSTEM / AREA	SURGICAL SUITE	RECOVERY AREA	ICU/CCU	LABOR & DELIVERY	NURSERY & OB UNIT	TEACHING	UNDEVELOPED SURGICAL	OPTHAL CLINIC	
4.0 Interior Finish									
4.1 Austere	52.68	16.70	7.71	12.20	14.00	6.36	43.68	12.20	
4.2 Average	58.57	18.57	8.57	13.57	15.57	7.07	48.57	13.57	
4.3 Generous	67.41	21.37	9.86	15.62	12.92	8.14	55.90	15.62	
5.0 Roof System	-	-	-	-	-	-	-	-	
6.0 Casework	8.00	1.00	5.28	1.00	5.28	1.00	5.00	5.28	
7.0 Plumbing	10.35	7.85	5.90	7.85	6.56	3.86	2.35	4.85	
8.0 Heating, Ventilating and Air Conditioning									
8.1 All Air/ Induction	28.46	10.63	10.63	21.47	7.42	9.67	6.44	10.74	
8.2 All Air/ Fan Coil	28.19	10.53	10.53	21.27	7.35	9.53	6.38	10.64	
8.3 All Air/ Incremental	26.85	10.03	10.03	20.26	7.00	9.12	6.08	10.13	
9.0 Electrical	11.65	7.77	11.65	7.77	9.71	4.86	2.91	5.83	
10.0 Elevators	-	-	-	-	-	-	-	-	

*Costs of test configuration.

[illegible] COSTS BY LEVEL, AREA AND BUILDING SYSTEM
(DOLLARS/SF)

LEVEL: MEDICAL/ ADMINISTRATIVE

BUILDING SYSTEM / AREA	NEUROPSYS CLINIC	WELFARE & ETC.	UNDEVELOPED CLINIC	ADMINISTRATION	MAJ. CIRC.	PRIMARY NODES	SECONDARY NODES	TOTAL COSTS
1.0 Foundations	-	-	-	-	-	-	-	-
2.0 Super Structure								
2.1 Steel frame, concrete fireproofing and slabs (US Steel Scheme)	8.18	8.18	8.18	8.18	8.18	11.24	11.24	8.43*
2.2 Steel frame, concrete fireproofing and slabs (Bethlehem Scheme A)	9.75	9.75	9.75	9.75	9.75	13.40	13.40	[illegible]
2.3 Steel frame, concrete fireproofing, and slabs (Bethlehem Scheme B)	9.46	9.46	9.46	9.46	9.46	13.00	13.00	9.75
2.4 Steel frame, concrete fireproofing, and slabs (Bethlehem Scheme C)	6.21	6.21	6.21	6.21	6.21	8.53	8.53	6.4[illegible]
2.5 Reinforced concrete slabs, beams columns	8.85	8.85	8.85	8.85	8.85	12.16	12.16	9.1[illegible]
2.6 Metal deck & Concrete slab (Inpatient level only)	-	-	-	-	-	-	-	-
2.7 Precast Concrete (Inpatient level only)	-	-	-	-	-	-	-	-
3.0 Exterior Wall								
3.1 Face Brick, Masonry Back-up (Cavity)	-	-	-	6.02	-	-	-	4.7[illegible]
3.2 Face Brick, Masonry Back-up (solid)	6.43	6.43	6.43	6.43	-	-	-	5.07*
3.3 Stucco Facing, Blockwall	-	-	-	5.47	-	-	-	4.3[illegible]
3.4 Precast Concrete Panels	-	-	-	7.56	-	-	-	5.9[illegible]
3.5 Glass & Metal Panels	-	-	-	7.79	-	-	-	6.1[illegible]

NGMH T_O COSTS BY LEVEL, AREA AND BUILDING SYSTEM (DOLLARS/SF)

LEVEL: MEDICAL/ ADMINISTRATIVE

BUILDING SYSTEM / AREA	NEUROPSYS CLINIC	WELFARE & REC.	UNDEVELOPED CLINIC	ADMINISTRATION	Maj. Circ.	PRIMARY NODES	SECONDARY NODES	TOTAL COSTS	
4.0 Interior Finish									
4.1 Austere	12.20	5.73	10.68	6.63	9.71	22.49	22.49	18.24	
4.2 Average	13.57	6.37	11.87	7.37	10.80	25.00	25.00	20.28*	
4.3 Generous	15.62	7.33	13.66	8.48	12.43	28.78	28.78	23.35	
5.0 Roof System	-	-	-	-	-	-	-	-	
6.0 Casework	5.28	1.00	1.00	1.00	-	-	-	3.00*	
7.0 Plumbing	4.35	3.66	2.15	4.10	1.00	-	-	4.43*	
8.0 Heating, Ventilating and Air Conditioning									
8.1 All Air/ Induction	10.74	9.50	6.18	8.48	9.56	-	-	10.65	
8.2 All Air/ Fan Coil	10.64	9.47	6.12	8.40	9.47	-	-	10.55	
8.3 All Air/ Incremental	10.13	9.02	5.83	8.00	9.02	-	-	10.05*	
9.0 Electrical	5.83	3.88	2.91	3.88	4.85	1.94	1.94	6.05*	
10.0 Elevators	-	-	-	-	-	-	-	-	

*Costs of test configuration

NGMH T_O COSTS BY LEVEL, AREA AND BUILDING SYSTEM
(DOLLARS/SF)

LEVEL: SERVICE

BUILDING SYSTEM / AREA	MECHANICAL	CENTRAL SUPPLY	HOUSEKEEPING	DIETARY	PHYSICAL THERAPY	WAREHOUSE		
1.0 Foundations	-	-	-	-	-	-		
2.0 Super Structure								
2.1 Steel frame, concrete fireproofing and slabs (US Steel Scheme)	16.29	14.05	14.05	11.24	11.24	14.61		
2.2 Steel frame, concrete fireproofing and slabs (Bethlehem Scheme A)	28.10	24.24	24.24	19.39	19.39	25.20		
2.3 Steel frame, concrete fireproofing, and slabs (Bethlehem Scheme B)	26.41	22.78	22.78	18.22	18.22	23.68		
2.4 Steel frame, concrete fireproofing, and slabs (Bethlehem Scheme C)	12.20	10.52	10.52	8.42	8.42	10.94		
2.5 Reinforced concrete slabs, beams columns	28.50	24.59	24.59	19.67	19.67	25.57		
2.6 Metal deck & Concrete slab (Inpatient level only)	-	-	-	-	-	-		
2.7 Precast Concrete (Inpatient level only)	-	-	-	-	-	-		
3.0 Exterior Wall								
3.1 Face Brick, Masonry Back-up (Cavity)	2.21	2.21	2.21	2.21	2.21	2.21		
3.2 Face Brick, Masonry Back-up (solid)	2.44	2.44	2.44	2.44	2.44	2.44		
3.3 Stucco Facing, Blockwall	2.08	2.08	2.08	2.08	2.08	2.08		
3.4 Precast Concrete Panels	2.92	2.92	2.92	2.92	2.92	2.92		
3.5 Glass & Metal Panels	3.01	3.01	3.01	3.01	3.01	3.01		

NGMH To

COSTS BY LEVEL, AREA AND BUILDING SYSTEM
(DOLLARS/SF)

LEVEL: SERVICE

BUILDING SYSTEM \ AREA	MECHANICAL	CENTRAL SUPPLY	HOUSEKEEP-ING	DIETARY	PHYSICAL THERAPY	WAREHOUSE			
4.0 Interior Finish									
4.1 Austere	1.94	8.00	8.06	11.83	14.19	6.65			
4.2 Average	2.06	8.50	8.56	12.56	15.06	7.06			
4.3 Generous	2.16	8.96	8.96	13.14	15.76	7.39			
5.0 Roof System	-	-	-	-	-	-			
6.0 Casework	-	-	1.50	2.11	1.50	-			
7.0 Plumbing	5.10	.25	.35	2.75	2.00	.25			
8.0 Heating, Ventilating and Air Conditioning									
8.1 All Air/ Induction	2.14	1.79	1.53	9.08	8.07	1.27			
8.2 All Air/ Fan Coil	2.12	1.78	1.51	9.00	8.00	1.26			
8.3 All Air/ Incremental	2.02	1.69	1.44	3.57	7.61	1.20			
9.0 Electrical	19.37	4.84	4.84	7.75	5.81	1.94			
10.0 Elevators	-	-	-	-	-	-			

*Costs of test configuration.

NGMH T_0 COSTS BY LEVEL, AREA AND BUILDING SYSTEM
(DOLLARS/SF)

LEVEL: SERVICE

BUILDING SYSTEM / AREA	STAFF SERVICES	MAJOR CIRC.	PRIMARY NODES	UNDEVELOPED SPACE	TOTAL COSTS			
1.0 Foundations	-	-	-	-	-			
2.0 Super Structure								
2.1 Steel frame, concrete fireproofing and slabs (US Steel Scheme)	11.24	14.05	11.80	14.05	13.49*			
2.2 Steel frame, concrete fireproofing and slabs (Bethlehem Scheme A)	19.39	24.24	20.35	24.24	23.27			
2.3 Steel frame, concrete fireproofing, and slabs (Bethlehem Scheme B)	18.22	22.78	19.13	22.78	21.87			
2.4 Steel frame, concrete fireproofing, and slabs (Bethlehem Scheme C)	8.42	10.52	8.83	10.52	10.10			
2.5 Reinforced concrete slabs, beams columns	19.67	24.59	20.65	24.59	23.61			
2.6 Metal deck & Concrete slab (Inpatient level only)	-	-	-	-	-			
2.7 Precast Concrete (Inpatient level only)	-	-	-	-	-			
3.0 Exterior Wall								
3.1 Face Brick, Masonry Back-up (Cavity)	2.21	-	-	2.21	1.95			
3.2 Face Brick, Masonry Back-up (solid)	2.44	-	-	2.44	2.15*			
3.3 Stucco Facing, Blockwall	2.08	-	-	2.08	1.83			
3.4 Precast Concrete Panels	2.92	-	-	2.92	2.57			
3.5 Glass & Metal Panels	3.01	-	-	3.01	2.65			

NGMH T_O COSTS BY LEVEL, AREA AND BUILDING SYSTEM
(DOLLARS/SF)

LEVEL: SERVICE

BUILDING SYSTEM \ AREA	STAFF SERVICES	MAJOR CIRC.	PRIMARY MODES	UNDEVELOPED SPACE	TOTAL COSTS				
4.0 Interior Finish									
4.1 Austere	7.36	8.95	23.55	5.24	8.10				
4.2 Average	7.81	9.50	25.00	5.56	8.60*				
4.3 Generous	8.18	9.94	26.16	5.82	9.00				
5.0 Roof System	-	-	-	-	-				
6.0 Casework	1.00	-	-	-	.70*				
7.0 Plumbing	1.00	.50	-	.50	2.10*				
8.0 Heating, Ventilating and Air Conditioning									
8.1 All Air/ Induction	8.07	6.02	-	.76	4.40				
8.2 All Air/ Fan Coil	8.00	5.96	-	.76	4.36				
8.3 All Air/ Incremental	7.61	5.68	-	.72	4.15*				
9.0 Electrical	4.84	4.84	1.94	2.91	8.36*				
10.0 Elevators	-	-	-	-	-				

*Costs of test configuration.

NGMH T_O COSTS BY LEVEL, AREA AND BUILDING SYSTEM
(DOLLARS/SF)

LEVEL: INPATIENT

BUILDING SYSTEM / AREA	NURSING UNITS	LIGHT CARE UNITS	PRIMARY NODES	SECONDARY NODES (N.U.)	SECONDARY NODES (L.C.)	CIRCULATION LINKS	TOTAL	
1.0 Foundations	-	-	-	-	-	-	-	
2.0 Super Structure								
2.1 Steel frame, concrete fireproofing and slabs (US Steel Scheme)	7.46	7.46	9.55	9.55	9.55	7.46	7.87*	
2.2 Steel frame, concrete fireproofing and slabs (Bethlehem Scheme A)	7.46	7.46	9.55	9.55	9.55	7.46	7.87	
2.3 Steel frame, concrete fireproofing, and slabs (Bethlehem Scheme B)	7.46	7.46	9.55	9.55	9.55	7.46	7.87	
2.4 Steel frame, concrete fireproofing, and slabs (Bethlehem Scheme C)	7.46	7.46	9.55	9.55	9.55	7.46	7.87	
2.5 Reinforced concrete slabs, beams columns	6.00	6.00	7.68	7.68	7.68	6.00	6.33	
2.6 Metal deck & Concrete slab (Inpatient level only)	7.46	7.46	9.55	9.55	9.55	7.46	7.87	
2.7 Precast Concrete (Inpatient level only)	7.70	7.70	9.85	9.85	9.85	7.70	8.12	
3.0 Exterior Wall								
3.1 Face Brick, Masonry Back-up (Cavity)	2.98	2.98	-	-	-	2.98	2.40	
3.2 Face Brick, Masonry Back-up (solid)	3.25	3.25	-	-	-	3.25	2.62*	
3.3 Stucco Facing, Blockwall	2.73	2.73	-	-	-	2.73	2.20	
3.4 Precast Concrete Panels	3.84	3.84	-	-	-	3.84	3.10	
3.5 Glass & Metal Panels	3.96	3.96	-	-	-	3.96	3.19	

NC[illegible] COSTS BY LEVEL, AREA AND BUILDING SYSTEM
(DOLLARS/SF)

LEVEL: INPATIENT

BUILDING SYSTEM / AREA	NURSING UNITS	LIGHT CARE UNITS	PRIMARY NODES	SECONDARY NODES ([illegible] U.)	SECONDARY NODES (L.C.)	CIRCULATION LINKS	TOTAL		
4.0 Interior Finish									
4.1 Austere	6.42	5.89	20.95	20.95	20.95	5.46	9.15		
4.2 Average	7.35	6.75	24.00	24.00	24.00	6.25	10.48*		
4.3 Generous	9.47	8.69	30.91	30.91	30.91	8.05	13.10		
5.0 Roof System	-	-	-	-	-	-	-		
6.0 Casework	3.00	2.00	-	-	-	-	2.30*		
7.0 Plumbing	6.00	3.35	-	-	-	1.00	4.36*		
8.0 Heating, Ventilating and Air Conditioning									
8.1 All Air/ Induction	5.35	5.35	-	-	-	9.28	4.35		
8.2 All Air/ Fan Coil	5.30	5.30	-	-	-	9.19	4.31		
8.3 All Air/ Incremental	5.05	5.05	-	-	-	8.75	4.10*		
9.0 Electrical	7.58	5.68	1.89	1.89	1.89	1.89	6.11*		
10.0 Elevators	-	-	-	-	-	-	-		

*Costs of test configuration.

NGMH TEST CONFIGURATION: INITIAL COST (TO)
(DOLLARS/SF)

BUILDING SYSTEM	COST
1.0 FOUNDATION (Normal)	$ 3.00 S/F
2.0 SUPERSTRUCTURE	
2.1 Steel Frames, Concrete Fireproofing & Slabs	9.15
3.0 EXTERIOR WALL	
	3.15
4.0 INTERIOR FINISH	
4.2 Average	12.60
5.0 ROOF	.85
6.0 CASEWORK	2.00
7.0 PLUMBING	3.60
8.0 HEATING, VENTILATING & AIR CONDITIONING	
8.3 All Air/Incremental	7.00
9.0 ELECTRICAL	6.55
10.0 ELEVATORS	1.10
TOTAL	$ 49.00 S/F

APPENDIX 3.3-1

MEDICAL RECORDS FLOW, STORAGE AND RETRIEVAL

Westinghouse has recognized the need for a storage and retrieval sub-system that is capable of interfacing with larger hospital information systems that do not use microfilm as a storage medium. When integrated with the hospital information system such a sub-system, as will be described, will greatly enhance the ability of the total system to fulfill the user requirements of the NGMH.

Present System

Figure 1 illustrates the conventional flow of medical records in the BLHC System, starting at point X in the Admitting Department. Admissions personnel check a file or computer to see if the patient has any previous records on file. If so, a file request is sent to the Medical Records Department. The record is then sent to the appropriate ward, and becomes part of the patient's chart, which is periodically updated during the patient's stay. When the patient is discharged, there is a time delay while the physician prepares and files his discharge summary.

Data Flow Problems

Data flow problems begin when Admissions attempts to determine the patient's history. Perhaps the patient was previously admitted, but records are not available. If it can be established that the patient was admitted before, a request must be completed and sent to the Medical Records Department, requiring a messenger and producing a time delay. The Medical Records Department often adds to delays when they cannot find the record, two people want the same record, the record is already out, or the record was never refiled from the last time the patient was in the facility. Additional problems with present data flow are detailed on Figure 2.

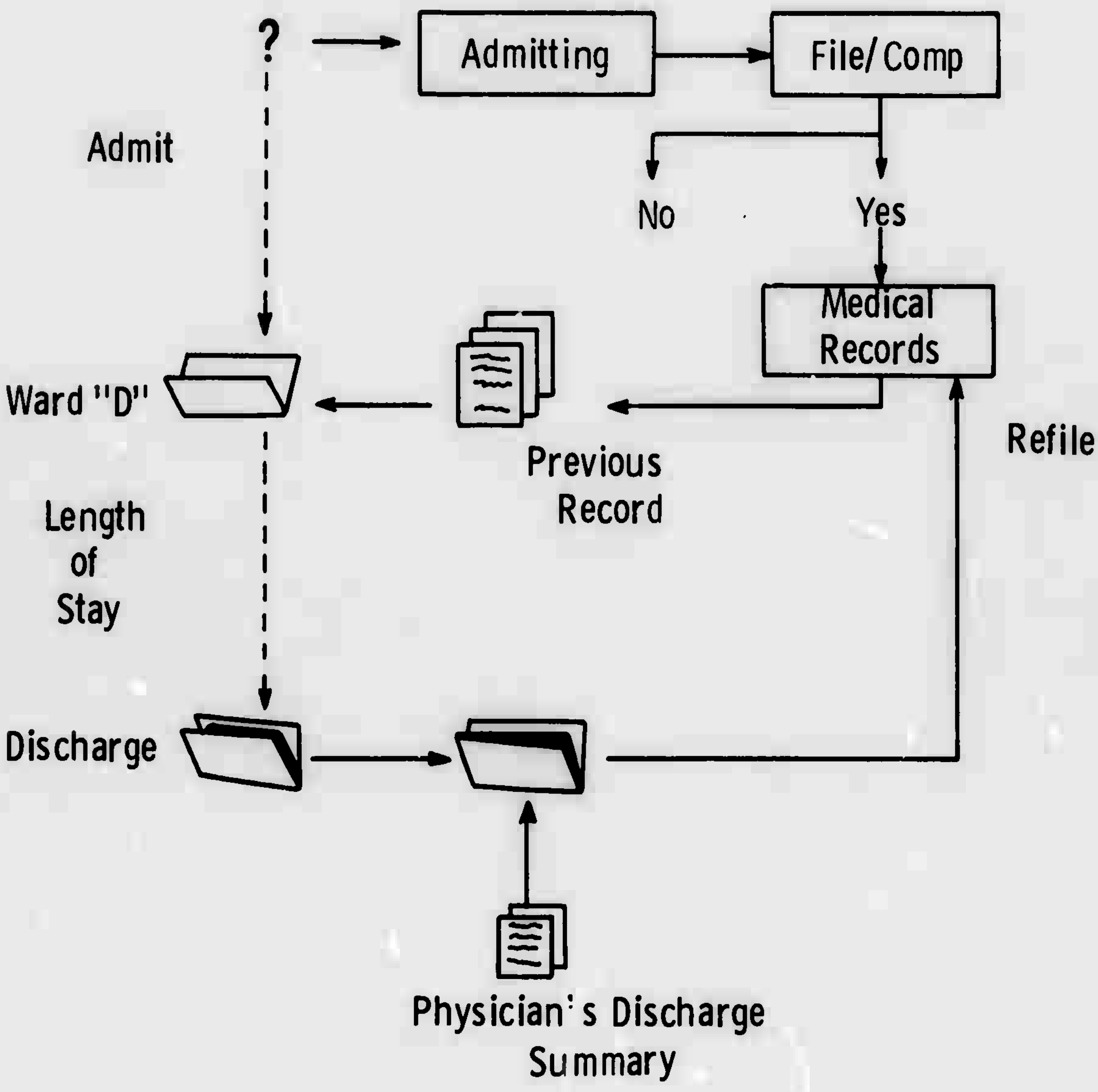


FIGURE 1. CONVENTIAL MANUAL SYSTEM.

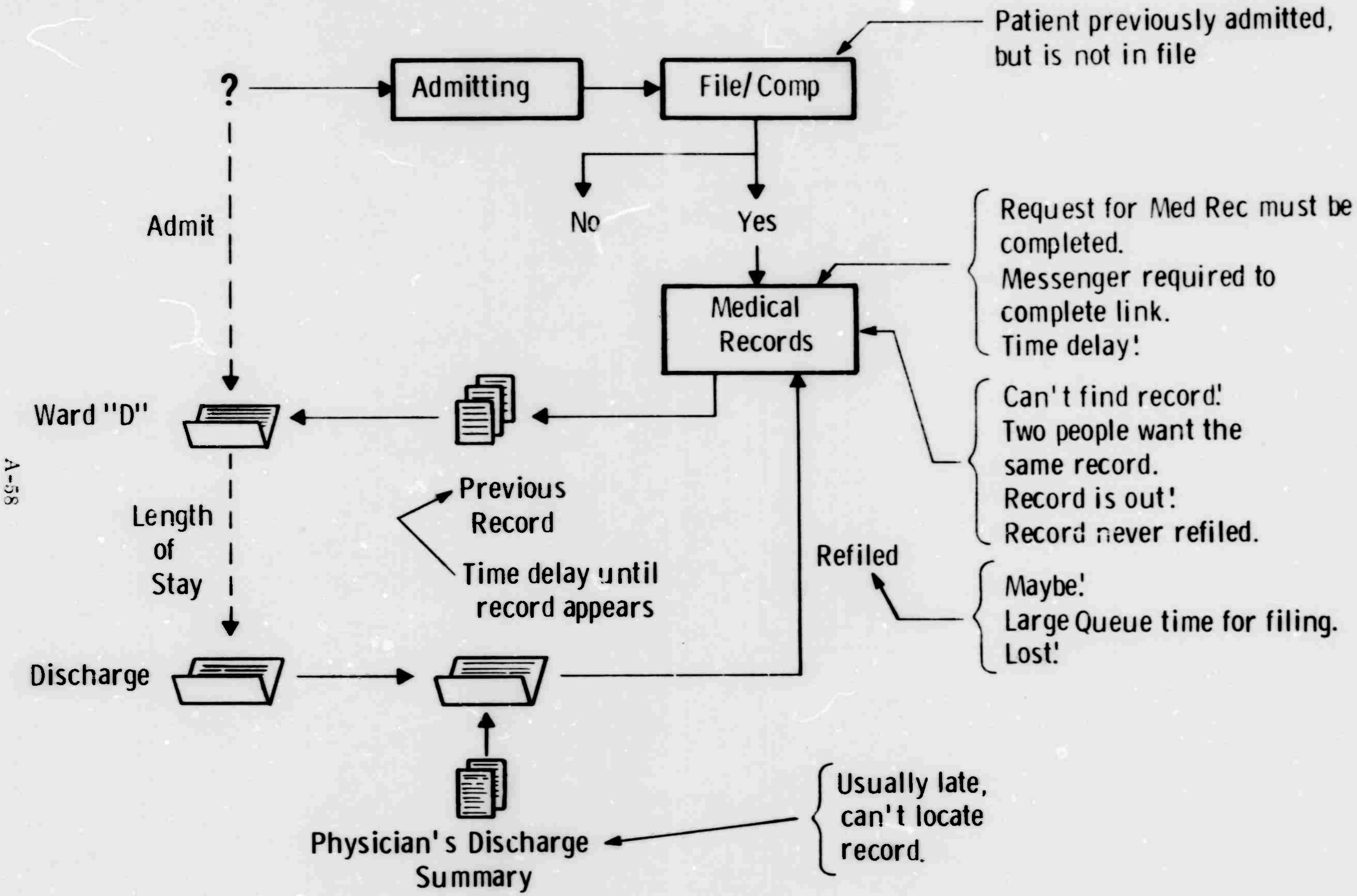


FIGURE 3. TYPICAL PROBLEMS WITH PRESENT DATA FLOW.

Solutions to Data Flow Problems

Using the integrated information network shown in Figure 3, a computer terminal in the Admitting Department is part of any one of the ten improvement alternatives. (pg. 3.3-26). To determine if a patient has been in the facility before, his last name or serial number is entered in the terminal by typing which directly accesses a computer and a microfilm storage device capable of storing up to 25 million pages of microfilm information and locating any given record within seconds. The need for filling out medical record requests and for personnel to pull medical records is eliminated, as records are automatically retrieved and brought to the proper location for duplication. At that point, a microfilm copy is made, and the stored microfilm returns to its original location. Two people can access the same record simultaneously.

After retrieval, a microfilm copy is sent to the appropriate nursing station where it is read on a microfilm reader. During the patient's stay, patient information is stored in the computer memory; upon his discharge, the physician's summary is also entered into the computer memory for real time access.

The patient's previous medical record, on microfilm, and his new records are combined upon discharge. The microfilmed medical record is destroyed since the original is in the microfilm storage device. The computer creates additional microfilm via COM (Computer Output Microfilm) which generates additional microfilm copies. If a COM service bureau is used, the data processing center electronically sends the patient's record by telephone lines to the service bureau, which in turn creates properly indexed microfilm, returning it to the Medical Records Department. Upon receipt, the Medical Records Department makes a duplicate microfilm to replace the outdated patient's record, and places the updated records in the microfilm storage device. Records older than 5 years are automatically purged and stored on master microfilm, considerably reducing the space now needed for medical records.

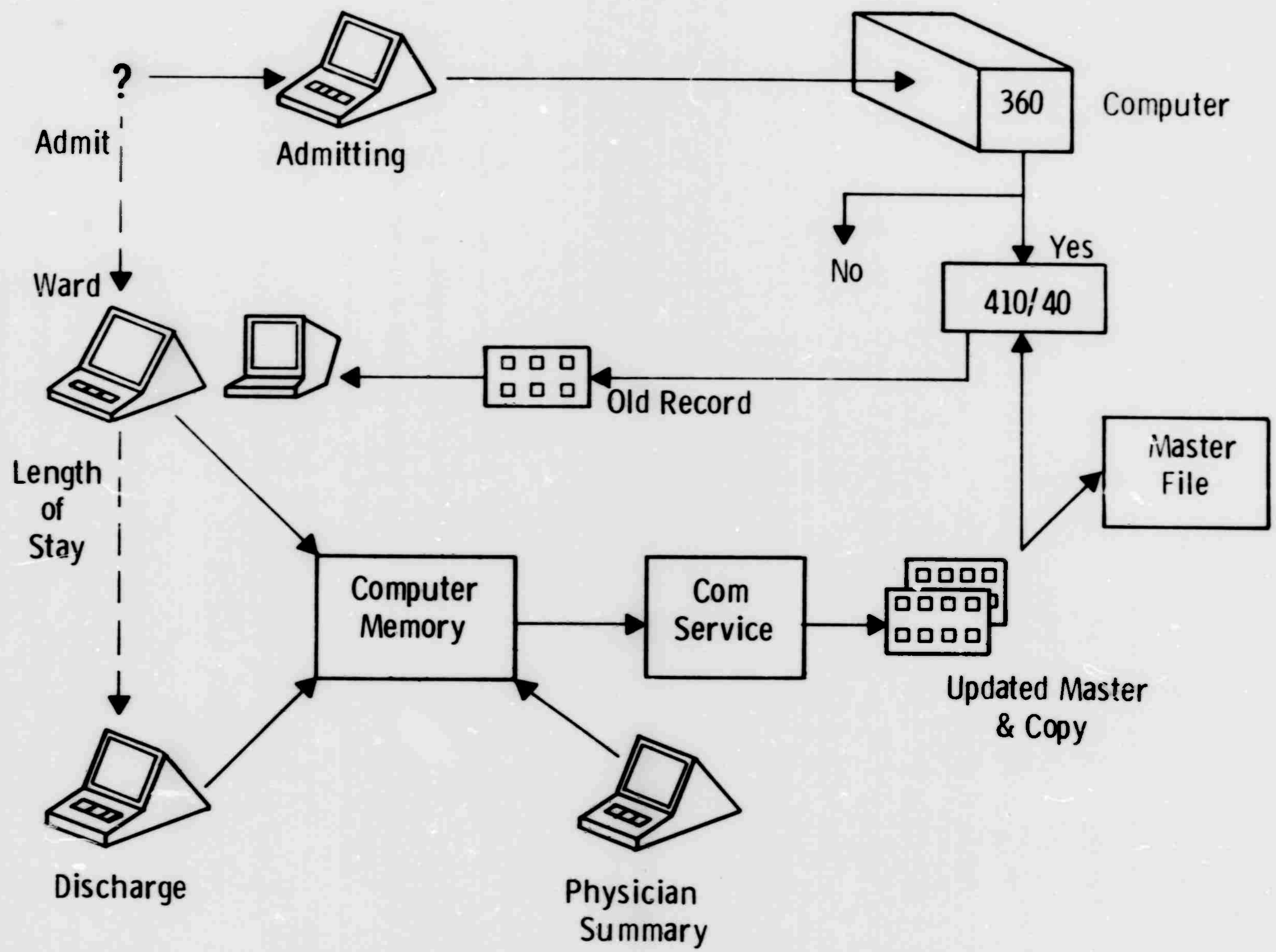


FIGURE 3. INTEGRATE INFORMATION NETWORK.

APPENDIX 3.3-2
WARD MANAGEMENT
UNIVERSITY OF MICHIGAN STUDY

The University of Michigan approach was used to evaluate present staffing and organization procedures to determine the areas in which quality and cost of care improvement are possible, to establish criteria for measuring improvement, and to establish a data base from which staffing and organization procedures can be reliably and efficiently installed in a new hospital.

The study, then, had a dual purpose: to evaluate, in terms of cost/quality, staffing and organization as it presently exists and to apply these data to determine staffing and organization needs required to achieve a defined quality level within a specific nursing unit or hospital.

Improvement in staffing and organization is a function of cost and quality of care. Ideally, any study recommendations should improve quality and reduce cost; in practice, this dual achievement is difficult.

Cost varies directly with staff size; as the number of staff hours per patient day varies, so will the cost per patient. Because of this direct relationship, staff hours per patient is used as the cost base in this study.

"Quality" is measured by the level of service provided; it cannot be measured quantitatively, and therefore, is measured by:

(a) A quality index based on sample observations of the presence or absence of certain attributes associated with the quality of patient care (See Figure 999).

(b) Expert judgment by professional nurses.

(c) The perception of nurses working on the patient units concerning quality of care on their unit.

WORK SHEET

Hospital Unit ______________________ Bed No. ______________________

Date ______________________

Time ______________________

PATIENT'S CHART

Factor No.		YES	NO	NA
.01	Have medications been given as ordered? - - - - - -			
.02	Have medications been charted correctly? - - - - -			
.03	Are reasons for and effect of PRN, STAT and onetime medications charted on nurses' notes? - - -			
.04	Have treatments been given as ordered?- - - - - - -			
.05	Have treatments been charted correctly? - - - - - -			
.06	Have vital signs been taken as ordered? - - - - - -			
.07	Have vital signs been recorded correctly? - - - - -			
.08	Is intake and output record current?- - - - - - - -			
.09	Of orders are not carried out, have pertinent comments been recorded? - - - - - - - - - - - - - -			
.10	Have all orders been dated and signed by physician?- - - - - - - - - - - - - - - - - - - -			
.11	Was notification and response of physician charted?- -			
.12	Are pertinent recurring activities charted? - - - -			
.13	Do the nursing notes reflect existing patient or family teaching?- - - - - - - - - - - - - - - - -			
.14	Are nurses' notes legible?- - - - - - - - - - - - -			
.15	Are approved abbreviations being used?- - - - - - -			
.16	Are recorder's signature and initials noted?- - - -			
.17	Is the patient's full name recorded on the medication card?- - - - - - - - - - - - - - - - - - -			
	TOTAL	___	___	___

Observer comments (reference backup information if available):

Factor No.	

Fig. 1 —Quality evaluation work sheet

The "quality index" is a quality measurement derived from statistical sampling (not "Statistical Quality Control" as defined by statisticians or others). The procedures for estimating (or measuring) quality is an adaptation of the methodology tested at VAH, Long Beach, California in 1966. Specific factors reflecting quality have been developed so that random samples of qualitative data can be collected by registered nurses. Quality factors utilized include patient safety, welfare, comfort, environment, and specific items relative to continuity of care.

In all previous studies, the three quality measurement methods came to similar conclusions when evaluating similar nursing units. Because of this close correlation of results, Westinghouse decided to utilize only the third measurement, working nurse's perception, since it integrated best with the data inventory methodology.

The questionnaire used to evaluate quality is contained in Appendix XII of the Data Inventory volume. Questions regarding education, age, training, tenure, impressions of job activities, working conditions and overall ratings of patient care were asked of professional nurses, corpsmen and administrators. Their answers were used to evaluate the workings and quality of staffing and organization on their unit.

General Conclusions from Civilian Study

While organizational change is only one factor affecting cost and quality, it is an important one in that it can enhance the quality/cost relationship by:

1. Improving staff quality (higher education, experience, and training normally means higher quality).
2. Reducing turnover which results in higher performance.
3. Reducing administrative and clerical work by professional personnel.
4. Providing participative management and clear job descriptions which lead to greater personnel satisfaction and higher performance.
5. Encouraging integration of education and research programs into the normal workload.

The comparison of high-efficiency to low-efficiency patient units at civilian hospitals resulted in the following conclusions:

1. Quality increases as non-professional activities are transferred to non-professional personnel.
2. High-efficiency units employ participative management to keep employees informed of management decisions and have supportive supervisors.
3. Employees in high-efficiency units completely understand their responsibilities.
4. Employees in high efficiency units have longer average hours of duty, resulting in better performance.
5. Personnel satisfaction is highest in high efficiency units.

Applying The University of Michigan Study to Military Hospitals

Westinghouse applied the principles of the University of Michigan study to Walson, Malcolm Grow, and Beaufort Hospitals to determine the study's applicability to military hospitals. The identical patient unit questionnaire was used, in conjunction with extensive interviews with Ward Masters and Unit Nurses. The Westinghouse conclusion is that comparability is high, and that the University of Michigan procedures can be applied to military hospitals with confidence.

APPENDIX 3.3-3

SELECTING ALTERNATIVES FOR COST/BENEFIT ANALYSIS IN THE FIELD OF EDUCATION AND TRAINING

Fifteen improvement alternatives to the current system which meet cost and effectiveness criteria to varying degrees were investigated during state-of-the-art and data inventory studies.

The fifteen improvement alternatives are:

A. Programmed Instruction

1. Linear programmed instructional tests PI(L)
2. Branching programmed instructional texts PI(B)
3. Linear programmed teaching machines TM(L)
4. Teaching machines with branching programmed instruction TM(B)

B. Learner Centered Audio Visual Devices

5. Sound motion pictures Learner Center Devices (Snd MP)
6. Silent motion pictures Learner Center Devices (Sil MP)
7. Sound filmstrips Learner Center Devices (Snd FS)
8. Sound filmstrip cartridge (Snd FS Cart)

C. Instructional Television

9. Closed circuit television without feedback (CCTV w/o f)
10. Closed circuit television with feedback (CCTV w/f)
11. Video tape recording and playback systems (VTR)

D. Dial Access Information Retrieval Systems (DAIRS)

12. Scheduled audio only (DAIRS A)
13. Scheduled audio-video DAIRS (A/V)
14. Random audio-video DAIRS (R)

E. Computer Assisted Instruction

15. Computer based teaching machines with branching and sound motion picture capabilities (TM- B-Snd MP)

The alternatives were evaluated in terms of:

A. Effectiveness. Effectiveness of an alternative is the extent to which it facilitates or constrains student stimulus, response, evaluation, and prescription, all of which can be further divided into dimensions and attributes. Table I quantitatively evaluates relative effectiveness by assigning a numerical weight to each attribute by facilitating or constraining traits.

A plus number is used if the attribute facilitates, a minus number if the attribute constrains student stimulus, response, evaluation and prescription. A composite rating is the sum of the four numerical evaluations.

B. Cost. Table II depicts the relative importance of personnel, materials, equipment, and facilities costs to total costs. Table III depicts the student hour costs of each alternative, based on average initial and operating costs to provide 150, 450 and 1350 hours of instruction to 200, 600 and 1800 students.

C. Sensitivity Index. A sensitivity index was established to determine each alternative's sensitivity to changes in student load and course duration. The index is based on the assumption that as student numbers increase costs decrease if the same presentation is shared by the additional students.

Table IV shows sensitivity indexes for each alternative. The more feasible alternatives are those which show the greatest economies with increased student load or duration; they carry the highest index numbers.

Conclusions

Table V summarizes the evaluation. The alternatives were regrouped by number of encoding forms available, a measure of flexibility. Group A is the most flexible, Group D the least. Other evaluation criteria include the

Table I: Relative Effectiveness of Various Media

MEDIA	STIMULUS	RESPONSE	EVALUATION	PRESCRIPTION	COMPOSITE
I. PI (L)	+ 1	+ 2	+ 2	+ 2	+ 7
PI (B)	+ 1	+ 2	+ 2	+ 4	+ 9
TM (L)	+ 5	---	+ 2	+ 2	+ 9
TM (B)	+ 5	---	+ 2	+ 2	+ 9
II. LCD (snd MP)	+ 3	- 4	- 5	- 7	- 13
LCD (Sil MP)	+ 1	- 4	- 5	- 7	- 15
LCD (Snd FS)	+ 2	- 4	- 5	- 7	- 14
(Snd FS Cart)	+ 2	- 4	- 5	- 7	- 14
III. CCTV (w/o f)	+ 3	- 4	- 5	- 7	- 13
CCTV (w/f)	+ 3	- 2	+ 1	+ 3	+ 5
IV. DAIRS (A)	- 3	- 4	- 5	- 7	- 19
DAIRS (A/V)	+ 3	- 4	- 5	- 7	- 13
DAIRS (R)	+ 3	- 4	- 5	- 7	- 13
V. CAI	+ 5	+ 2	+ 2	+ 4	+ 13
Teacher-Pupil Method	+ 6	+ 4	+ 5	+ 7	+ 22
	Max. Score	Max. Score	Max. Score	Max. Score	
	+ 6	+ 4	+ 5	+ 7	+ 22

Table II: Relative Significance of Various Support Requirements

MEDIA	PERSONNEL	MATERIALS	EQUIPMENT	FACILITIES
I. PI (L)	min.	dom.	min.	min.
PI (B)	min.	dam.	min.	min.
TM (L)	min.	mod.	mod.	min.
TM (B)	min.	min.	ext.	min.
II. LCD (Snd MP)	min.	mod.	mod.	min.
LCD (Sil MP)	min.	mod.	min.	min.
LCD (Snd FS)	min.	mod.	mod.	min.
(Snd FS Cart)	min.	min.	ext.	min.
III. CCTV (w/o f)	min.	dom.	min.	min.
CCTV (w/f)	min.	dom.	min.	min.
VTR	min.	ext.	mod.	min.
IV. DAIRS (A)	min.	dom.	min.	min.
DAIRS (A/V)	min.	ext.	min.	min.
DAIRS (R)	min.	ext.	mod.	min.
V. CAI	min.	mod.	mod.	min.
Teacher-Pupil Method	ext.	mod.	min.	min.

Minimum = 0 - 25% of total summary cost
Moderate = 26 - 50% of total summary cost
Extensive = 51 - 75% of total summary cost
Dominant = 76 - 100% of total summary cost

Table III: Student Hour Costs of Various Media *

MEDIA	SUMMARY	INITIAL	OPERATING	MATERIALS
I. PI (L)	$ .84	$ .16 (19%)	$ .68 (81%)	$ .76 (90%)
PI (B)	.97	.21 (22%)	.76 (78%)	.85 (88%)
TM (L)	$ 1.75	$ 1.12 (64%)	$ .63 (36%)	$ .57 (33%)
TM (B)	7.42	6.56 (88%)	.86 (12%)	1.02 (14%)
II. LCD (Snd MP)	$59.92	$45.76 (76%)	$14.16 (24%)	$17.66 (29%)
LCD (Sil MP)	43.40	29.58 (68%)	13.82 (32%)	17.14 (39%)
LCD (Snd FS)	6.65	4.02 (61%)	2.54 (39%)	2.86 (44%)
(Snd FS Cart)	16.25	13.70 (84%)	2.55 (16%)	2.86 (18%)
III. CCTV (w/o f)	$ 2.37	$ .49 (21%)	$ 1.88 (79%)	$ 2.23 (94%)
CCTV (w/f)	2.43	.65 (27%)	1.78 (73%)	2.34 (96%)
VTR	1.40	.71 (51%)	.69 (49%)	.84 (60%)
IV. DAIRS (A)	$ .81	$ .19 (23%)	$ .62 (77%)	$ .64 (79%)
DAIRS (A/V)	1.33	.46 (35%)	.87 (65%)	.98 (74%)
DAIRS (R)				
V. CAI	$66.94	$53.33	$15.02	$18.68 (28%)

* Per student hour based on an average student load of 600 student for 450 hours.

Table IV: Media Cost Sensitivity Indices *

MEDIA	LEARNING MATERIALS SENSITIVITY INDEX	SUMMARY COST SENSITIVITY INDEX
I. PI (L)	3.3	1.14
PI (B)	3.5	1.12
TM (L)	0.8	0.016
TM (B)	0.5	0.006
II. LCD (Snd MP)	0.6	0.0002
LCD (Sil MP)	0.8	0.0006
LCD (Snd FS)	1.0	0.0030
(Snd FS Cart)	0.6	0.0020
III. CCTV (w/o f)	5.5	1.0900
CCTV (w/f)	3.2	1.1000
VTR		0.1100
IV. DAIRS (A)	2.5	1.1600
DAIRS (A/V)	2.4	1.1110
DAIRS (R)		

* The larger the numerical indicator, the more favorable the cost sensitivity.

Table V: Comparative Analyses of All Reviewed Media

	MEDIA	# of Encoding Forms	Learner Paced	Group Scheduled	Learning Materials Production Costs	Learning Materials Sensitivity Index	Summary Cost	Summary Cost Sensitivity Index
A	TM (B Snd MP) *	5	X					
	CAI *	5	X					
	VTR	5		X	N/A	N/A	1.40	.11
	DAIRS (A/V)	5		X		2.4	1.33	1.11
	CCTV (w/o f)	5		X	2.34	5.5	2.43	1.09
	CCTV (w/f)	5		X	2.23	3.2	2.37	1.10
B	DAIRS (R) [a]	4	X					
	TM (B)	4	X		1.02	.5	7.42	.006
	TM (L)	4	X		.57	.8	1.75	.016
	LCD (Sn FS)	4	X		2.86	1.0	6.56	.003
	LCD (Sil MP)	4	X		17.14	.8	43.40	.0006
	LCD (Snd FS Cart)	4	X		2.86	.6	16.25	.002
	LCD (Sn MP)	4	X		17.76	.6	59.92	.0002
C	PI (B)	3	X		.85	3.5	.97	1.12
	PI (L)	3	X		.76	3.3	.84	1.14
D	DAIRS (A)	1		X	.64	2.5	.81	1.16

* These two media are out of the competitive cost range as a result of their early experimental and development stages.

a A recent breakthrough in scan conversion technology makes random dial access a distinct possibility by 1972.

alternative's ability to be learner paced and group scheduled, and the cost of producing learning materials per student. Specific conclusions are:

1. There are direct relationships between learning materials format and production costs.
2. DAIRS (A) has the most favorable summary cost and summary cost index, however, these advantages are outweighed because this alternative can only be group scheduled.
3. The variety of encoding forms is contingent upon learning materials formats.
4. CAI is the only alternative offering five encoding forms plus individualized instruction, making it highly effective and flexible. It is, however, experimental and therefore expensive.
5. Generally, the ability to individualize instruction is coupled with high materials and summary costs, and a low cost sensitivity index, with the exception of programmed instruction.
6. Non-automated formats (Group C) have lower costs.

Final Selection

On the basis of the data on Table V, selections for detailed analysis are:

1. PI(B)
2. LCD (Snd FS Cart)
3. CCTV - w/o FB
4. VTR
5. DAIRS (A/V)
6. TM (B Snd MP) computer based

APPENDIX 3.4-1
DESIGN PHILOSOPHY - PAIRWISE OPTIMIZATION PROGRAM

Adjacency Program Need

The total distance traveled between clinics is one measure of adjacency effectiveness. If one assumes that all trips are necessary, the problem is then one of minimizing the total volume of flow from each area times the distance between origin and destination. The optimal solution for minimal flow in an ambulatory zone of 15 clinics would require the examination of 1,307,674,368,000 combinations of layouts. A Westinghouse computer program reduces the computational time by systematically comparing pairs of areas, switching them until no further trade reduces the total flow. Although such a solution may not be optimal (since not all possible combinations are examined) it does provide a method of quickly determining an improved layout, or of verifying that the original layout submitted was a sound one.

ASSUMPTIONS FOR BASE "X" AMBULATORY ZONE ADJACENCIES

1. Major flows in the ambulatory zone will be those of patients, doctors, and hand-carried communications*.
2. The unit "costs" for physicians, patients, and communications flows were set equal and valued at one unit (i.e., the program optimizes flow volume only, not the cost of flow), except in one example, where the physician flow was made 60 times more important than the others, to determine the effect on adjacency.
3. Clinics and service areas to be included in the first level ambulatory zone are:

---

* The program can handle more flows than these (e.g., materiel handling) if provided with an input matrix.

Areas	Abbreviations Initial Computer Run	Revised Computer Run
Emergency	ER	ER
Medical Specialty	MD1, MD2	MED
Medical Records	MR	MR
Neuropsychiatry	NP	NP
OB/GYN	OB	OB
Ophthalmology	OPL	EYE
Orthopedics	OP1, OP2	ORT
Pediatrics	PD1, PD2	PED
Surgical	SUR	SUR
Medical Walk-in	WLK	WLK
Clinical Laboratory	CL1, CL2, CL3	CL
Pharmacy	PHR	PHM
Radiology	RD1, RD2, RD3	RAD
Primary Elevator Shafts	WM1, WM2	EL1, EL2
Patient Service (e.g., Post Office, Recreational Areas, Px, etc.)	PS1, PS2, PS3	PS

Dental, located on the first floor, has minimal relation to the other clinics, and was positioned in the layout where it most effectively handles its own patient workloads.

4. Assumptions for various flows were as follows:

PATIENT FLOW

a. Flow From Parking Lots to Clinics: The design philosophy assumes that patients with scheduled visits will park near the clinic they are to visit, and go directly to that clinic. Thus, adjacency is not affected (assuming clinic entrances are well marked).

First visit referrals to a walk-in clinic are assumed either to be treated in the walk-in clinic or scheduled to return another day to the appropriate clinic. The same day referral from walk-in to another clinic (other than service area) was assumed negligible.

b. Flow Between Clinics: Except for unusual circumstances (e.g., the necessity for a same day consultation to another clinic), there is no flow of patients between clinics. In this example it is assumed negligible in comparison to flows to service areas.

c. Flow Between Clinic and Service Areas:

- To Radiology

The demand model prediction for films exposed at Base "X" at T_0 is: (Printout of 5/22/70):

Type of Exam	Annual Number Films Exposed	÷	Avg. Films/Procedure	=	Number Patients
Fluoroscopic	26,712	÷	10	=	2,671
Other	170,324	÷	3.5	=	48,700
			TOTAL		51,371

51,371 annual visits ÷ 52 weeks/year = 990 visits per week.

The following clinic flow was based on a 69 day sample of the Radio-fluoroscopic log, Beaufort Naval Hospital:

Clinic	% of Flow	Corresponding Base "X" Flow (weekly)
Dental	1%	10
Eye	0	0
Emergency	12	118
Medical (walk-in and specialty)*	34	336
OB/GYN	0	0
Ortho	14	138
Peds	1	10

(Cont'd)

Clinic	% of Flow	Corresponding Base "X" Flow (weekly)
Surg. (incl. Urology and ENT)	4	39
Dispensaries	3	30
Wards	30	296**
Neuropsychiatric***	0	0

* Split 50-50 in matrix between Med. Specialty and Walk-in.
** Split 50-50 between EL1 (intensive) and EL2 (light care) elevators.
*** Beaufort had no N/P clinic. Assuming that Base "X" has no such clinic, the trips from N/P to Radiology may be set to 0.

Assume that orthopedics flows are 2 way (e.g. patient waits for film, orthoped interprets that day), 1/2 of walk-in films are two way, and all others are one way:

From Radiology	visits/week
Orthopedics	138
Walk-in	86
Wards	296
All Other	0

- To Medical Records

  Each walk-in patient picks up his record and returns to the walk-in clinic. This equals 790 per week. Emergency patients have records picked up by corpsmen (see hand-carried Communications).

- To Clinical Laboratories

  There are an average of .44 procedures per outpatient visit (Air Force Medical Management Data, FY67). Total outpatient visits=320,161 forBase"X"x .44 = 140,870 chits. (Since "procedures" = "chits" in Air Force reporting.) Assuming that for every chit there is a laboratory specimen obtained; then: 140,870 chits = 140,870 trips to lab. ÷ 52 weeks per year = 2570 trips/week.

The following breakdown by clinic was obtained from Andrews AF235 Annual Summary, FY67:

	No. Specimens	% Total	Base "X" (weekly)
Emergency	27,942	13	360
Medical *	55,557	26	720
OB/GYN	47,647	22	600
Orthopedics	8,945	4	110
Pediatrics	35,874	16	440
Surgery	31,391	14	380
Eye	575	0	0
N/P	5,648	2	60

If one assumes that light care inpatients going to the laboratory have a specimen drawn an average of every other day, then there are 75 trips per day or 375 trips per week from light care wards (elevator 2).

Return Trips:

The inpatients return to the wards, the outpatients return to their residencies.

- To Pharmacy

Total Prescriptions, Base "X"	Annual ÷ 52 =	Weekly
Outpatient	373,777	7,180
Inpatient	288,144	5,500
	85,632	1,680

* Split 50-50 between walk-in and specialty.

Inpatient prescriptions are picked up by ward personnel. The breakdown by clinic comes from an average of the three primary study hospitals (Refer to Patient Flow matrices, Data Inventory volume). Assuming that one outpatient prescription one trip to pharmacy (with no return):

	% from Study Hospitals	Base "X" Weekly
Emergency	8%	440
Eye	2%	110
Medical*	36%	1980
Surgical	10%	550
OB/GYN	13%	715
Orthopedics	2%	110
Pediatrics	24%	1320
Neuropsychiatric	2%	110
Other	2%	110

d. Flow Between Wards and Clinics: The percentage of inpatient clinic visits was averaged for the three primary study hospitals and equated to Base "X":

To Clinic	% Inpatient	Total Wk. Visits	#Inpt. Visits	EL1**	EL2**
Emergency	0		0	0	0
Medical Specialty	2	790	16	8	8
Neuropsychiatric	40	275	110	0	110
Pediatrics	0		0	0	0
OB/GYN	0		0	0	0
Eye	5	210	10	0	10
Orthopedics	5	485	24	12	12
Surgical	6	390	23	12	11
Walk-in	0		0	0	0

* Breakdown into Walk-in specialty assumed 50-50 split.

** Breakdown into intensive (EL1) and light (EL2) elevators is arbitrary.

PHYSICIAN FLOW

a. Elevator 1 flow

- To operating room; labor and delivery

  Assume 3320 operations/year (from three primary hospitals studied)

  Assume -- clinic contribution equals surgical procedure allocation in Beaufort data pack.

Specialty	Percentage	Procedure	Procedures/Day
General Surgery*	34%	1140	4.5
Orthopedics	18%	597	2.35
Gynecology	10%	332	1.30
Obstetrics		1955	5.35 (7 days/wk.)
Urology	9%	299	1.18
ENT	15%	498	1.96
Eye	4%	133	.52
Dental	1%	33	.13
Pediatrics*	5%	166	.65

Assume physicians go from office to OR and return to office for each operation (max. condition) then:

Trips per week (5 day week)	From Clinics to OR (L&D)	From OR (L&D) to Clinics
Surg. (incl. ENT and Urology)	38	38
Orthopedics	12	12
OB/GYN	44	44
Pediatrics	3	3
Eye	3	3
Dental	1	1

Emergency -- assume 10% of emergency visits require operatory treatment = 4 visits per week.

* Pediatrics broken out from General Surgical from one month sample of Beaufort OR log (Oct. 1969) where 13% of general surgical load was pediatric.

- To nursery -- Pediatrician checks new born babies, once if normal; 2-3 times if abnormal, assume an average of 1.2 times per birth, or 45 trips per week = 90 round trips.
- To ICU - CCU

  Patient census in ICU - CCU: 27

  Assume physician checks patient during routine ward rounds (already included under trips to wards) and then returns one more time during the day. Also assume physician in EDR checks patient in ICU-CCU if admitted for surgery.

  Assume: Number of Physicians equal:

1 orthopedic	
7 medical	cover ICU-CCU 1 extra
3 surgical	visit per day (max. condition)
1 pediatrician	

  Visits from EDR to ICU

  Assume of the 43 visits per week that 10% must go through ICU. This would then require 4 trips by physicians in Emergency to ICU.

Specialty Physician	Trips per Week	To ICU	Return
Orthopedic	5 trips	5	5
Medical Specialty	35 trips	35	35
Surg	15 trips	15	15
Peds	5 trips	5	5

- To Wards

  Assume 2 trips per day per physician, between elevator 1 and elevator 2. Number of physicians in outpatient clinics (based on current criteria) is as follows:

Clinic/Area	Physician	Weekly Trips
OB/GYN	5	25
Ortho	6	30
Eye	3	15
N/P	8	40
Med. Specialty	13	65
Surgical	5	25
Pediatrics	8	40
Walk-in	4	20
Emergency	1	5
	53 physicians =	265 elevator trips

- To Radiology from Wards:

  Assume 2 physicians go to Radiology once a day for consultation with the Radiologist or 10 trips per week.

Total Elevator #1 Flow:

Clinic/Area	OR and L&D		Nursery		ICU/CCU		Wards		Total	
	To	From	To	From	To	From	To	From	To	From
Emergency	4	4	0	0	4	4	5	5	13	13
Medical Specialty	0	0	0	0	35	35	65	65	100	100
Neuropsychiatry*	0	0	0	0	0	0	40	40	40	40
OB/GYN	44	44	0	0	0	0	25	25	69	69
Eye	3	3	0	0	0	0	15	15	18	18
Orthopedics	12	12	0	0	5	5	30	30	47	47
Pediatrics	3	3	45	45	5	5	40	40	93	93
Surgical	38	38	0	0	15	15	25	25	78	78
Walk-in	0	0	0	0	0	0	20	20	20	20
Radiology									10	10

* No neurosurgeon at Base "X".

b. Elevator #2 flow

- To wards = as in Section a, 265 trips each way.
- To administrative areas:

  Assume:

  Chief of clinic - 1 per day = 5 per week

  Other physicians - 1 per week

- Total Elevator #2 flow:

Clinic/Area	Wards		Admin.		Total	
	To	From	To	From	To	From
Emergency	5	5	1	1	6	6
Medical Specialty	65	65	17	17	82	82
Neuro Psychiatrist	40	40	12	12	52	52
OB/GYN	25	25	9	9	34	34
Eye	15	15	7	7	22	22
Orthopedics	30	30	10	10	40	40
Pediatrics	40	40	12	12	52	52
Surgical	25	25	9	9	34	34
Walk-in	20	20	4	4	24	24

c. To Radiology

Orthopedic: Assume 1 trip per day by one physician to discuss a case with Radiologist = 5 per week

Medical Specialty: Assume 10 physicians visit Radiology an average of every other day = 30 visits/week

Surgery: Negligible

Pediatrics: Assume cne physician once a day = 5 per week

Medical Walk-in: Assume one physician a day = 5 per week

d. To Clinical laboratory -- Negligible

e. To Pharmacy: negligible

HAND-CARRIED COMMUNICATIONS*

a. Medical Records

- Medical Records to Clinic 1 trip/day = 5 trips/week

  Clinic returns records 1 trip/day = 5 trips/week

*Normal administrative communiques not included.

- Walk-in to Medical Records - Picked up by patients (See Patient Flow)
- Emergency room to Medical Records

  32 trips/day x 7 days = 224 per week

Return of signed laboratory and radiology results are batched and brought back with records - no additional trips.

b. <u>Clinical Laboratory</u>

Patients carry chits to laboratory to have blood samples drawn (see patient flow). "Stat" results are telephoned to appropriate clinic (no hand-carried volume). Routine results taken to clinic once a day = 5 per week.

c. <u>Radiology</u>

- Routine results: batched and sent to appropriate clinic once a day = 5 per week.
- Stat results: carried with the patient who waits for results or, if the X-ray requires a Radiologist the results are telephoned to the appropriate clinic.
- Requests for previous X-ray films:

At Beaufort, there are an average of 200 patients per week (69 day log sample); 70 X-ray envelopes are requested per week (interview estimate): Thus, 70/210 = 33 % of patient load is an estimate for the number of X-ray envelopes requested. Assuming that clinic requests for old films follow the same percentage as the breakdown by patient visits, the film request is:

Clinic	Weekly Patient load . x .33 =	Films Requested/Week
Emergency	118	39
Walk-in	178	59
Med. Specialty	178	59
Ortho	138	46
Pediatrics	10	3

Clinic	Weekly Patient load x .33 =	Films Requested/Week
Surgical	39	13
EL1	148	49
EL2	148	49
Others	0	0

The reports are batched and returned at the end of the day = 5 trips per week.

d. Pharmacy

- Outpatient prescriptions: carried to pharmacy by patients (see patient flow matrix).
- Inpatient prescriptions: come down in the morning and are returned by pharmacy personnel in the afternoon.

  To pharmacy (with return) ELI: One trip/day from each ward, assuming a configuration of 6 wards at 2 levels = 8 per day = 40 per week.

  EL2: One trip/day from each ward = 4 per day = 20 per week.

5. Clinic sizes for Base "X" are those determined from existing DoD criteria. For adaptation to the program, the sizes were modularized into multiples of squares from center of square to center of square. The area approximations from Run Number One assumed the clinics would be multiples of 4,000 sq. ft. blocks.

Clinic name	Actual area	Units assigned	Remaining area
Emergency	2380	1	-1620
Medical	8590	1	+590
Medical Records	2670	1	-1330
Neuro/Psychiatry	3600	1	- 400
OB/GYN	5760	2	-2240
Ophthalmology	2950	1	-1050

Clinic name	Actual area	Units assigned	Remaining area	
Orthopedics	8700	2	+700	
Pediatrics	6910	2		-1090
Surgical	4980	1	+980	
Walk-in	4850	1	+850	
Clinical laboratories	10600	3		-1400
Pharmacy	5510	1	+1510	
Radiology	13620	3	+1620	
EL1	2700	1		-1300
EL2	2700	1		-1300
Patient Services	11700	3		- 400
	11,620	27	+6750	-12130

6. The initial layout consisting of the idealized areas is shown as follows:

```
      WLK       CL3  OPL
MD1   MD2  CL1  CL2  NP   DEN
MR    WM1  PHR  PS1  PS3  WM2
ER    OP1  RD1  PS2  OB1  PD1
SUR   OP2  RD2  RD3  OB2  PD2
```

7. Elevators 1 and 2 are fixed in location

8. All vertical flow takes place through primary nodes.

INITIAL RUN

From these initial criteria, the following computer runs were made:

- Adjacency considering all flows:

```
PD2  PD1  CL3  CL2  CL1
RD3  SUR  PS2  PS1  PS3  OPL
RD2  WM1  OB2  OB1  NP   WM2
RD1  MD1  MD2  PHR  ER   DEN
     OP2  OP1       WLK  MR
```

- Adjacency considering only patient flow:

	PD1	PS2	PS1	PS3	NP
	PD2	SUR	MD1	CL1	OPL
OB1	WM1	RD3	MD2	CL2	WM2
OB2	RD2	RD1	PHR	CL3	ER
	OP1	OP2	WLK	MR	DEN

- Adjacency with doctor flow multiplied by 60:

OP1	OP2	PS1	PS2	PS3	
RD3	SUR	PD2	PD1	OPL	ER
RD2	WM1	MD2	NP	DEN	WM2
RD1	WLK	MD1	MR	CL2	CL1
	OB2	OB1	PHR		CL3

Since the solutions are dependent upon the initial layout, several runs were made using different input layouts. Only the results of the runs giving lowest total flow are presented here. The problems which resulted with the output as it existed in the first runs were:

1) Clinics with high expansion capability were sometimes placed in non-expandable areas (i.e., the center zone of the building).
2) The block sizes did not correspond dimensionally with the original architectural scheme of 300' primary elevator separation, and often clinic areas were placed into central corridor space, hindering architectural conversion into plan drawings.

REVISED RUN

A new layout was idealized, constraining those areas with the least need for expansion to the center, and allowing the others to move about the perimeter until the best arrangement for flow was achieved. The constrained areas are:

Medical Records
Primary elevator nodes (EL1 and EL2)
Pharmacy
Patient Services (PS)

The revised initial layout for the computer optimization study is shown below:

WLK	MED	MED	CL	CL	CL	EYE	NP
ER	MR	EL1	PHM	PS	PS	PS	EL2
SUR	ORT	ORT	RAD	RAD	RAD	OB	PED

CONCLUSIONS

The computer solution of adjacency is only as good as the flow volumes which it is given to manipulate. The data collected by Westinghouse observers allowed a realistic picture of flow for this example. More importantly, the computer is easily adapted to different flows whose effects on adjacency can readily be seen. Three such changes were programmed for Base "X" at T_0:

<u>Run #1:</u> Combined physician, patient and hand-carried communications flow.

<u>Run #2:</u> Patient flow only (i.e., simulating the situation where doctors were organized around a group practice and did not have to move from their clinics, and where the need to hand-carry communications was eliminated by communications technology).

<u>Run #3:</u> Physician flow multiplied by 60. (i.e., simulating a design emphasizing ease in doctor movement).

- <u>Adjacency considering all flows:</u>

RAD	RAD	RAD	MED	MED	SUR	EYE	NP
WLK	MR	EL1	PHM	PS	PS	PS	EL2
ORT	ORT	ER	PED	OB	CL	CL	CL

- Adjacency considering only patient flow:

RAD	RAD	RAD	MED	MED	ER	EYE	NP
WLK	MR	EL1	PHM	PS	PS	PS	EL2
ORT	ORT	SUR	PED	OB	CL	CL	CL

- Adjacency considering doctor flow multiplied by 60:

CL	CL	OB	ER	MED	MED	EYE	NP
CL	MR	EL1	PHM	PS	PS	PS	EL2
ORT	ORT	SUR	PED	WLK	RAD	RAD	RAD

The main advantage of this program is its ability to predict the effects of changes in flow before construction or operation. There are other factors which may dictate adjacency besides flow volumes. This program is one of many tools to be used in the evolvement of a final design.

DYNAMIC PROGRAMMING

APPENDIX 3.4-2

Dynamic programming has been previously applied to the problem of long-range planning in the presence of uncertainty.[1,2] Here, the planning of both the initial facilities and the strategies for expansion of health care facilities in the presence of uncertainty about future demand is formulated as a dynamic programming problem. The entire planning interval is divided into subintervals. At discrete points in time (which define the subintervals), a decision is made concerning the expansion of facilities during the succeeding subinterval. The objective function at each decision point is the minimization of expected life cycle costs for the remaining portion of the planning interval. The life cycle costs are composed of acquisition costs (initial construction, expansion and equipping costs), operating costs (all costs other than acquisition costs incurred in the operation of the facilities), and penalty costs (for having insufficient capacity). Dynamic programming is used to determine the optimum strategy for sequentially expanding (or modifying) from one design to another, such that expected costs are minimized. This optimum expansion strategy is given in the form of a decision table for each planning point in time. These tables give the optimum strategy as a function of the current patient load and health care facility configuration. The health care system has light care, moderate care, intensive care, and outpatient capabilities. Two state variables, c(t) and d(t) model the facility and the patient demand, where

$c(t)$ = configuration of system at time t

$d(t)$ = total patient demand at time t

$t = 0, 1, 2, \ldots N$ (discrete planning times)

The vector p(t) is defined by

$$p(t) = q(t)\, d(t) \tag{1}$$

where the components of p(t) are intensive care, moderate care, light care, and outpatient demands. q(t) determines the relative numbers of patients in the different categories. This approach is taken for modeling the demand,

instead of using a different state variable for each type of demand, to obtain a computationally feasible dynamic programming problem.

The demand state, d(t), is defined by a Markov process.

$$d(t+1) = f\,(d(t),\ r(t),\ (t) = a(t)\ d(t) + r\ (t) \qquad (2)$$

where a (t) is a specified function of time and r(t) is a discrete stochastic variable. This model projects demand at time t + 1 based on the demand at time t but not on earlier demands, t-1, t-2, etc. a(t) is the deterministic portion of the projection, and r(t) represents the uncertainty or "fuzziness" associated with the projection.

The configuration state, c(t), is defined by the relationship

$$c(t + s) = c(t) + u(t)$$

where u(t) is the decision variable which changes the configuration. Δ is the delay encountered between the time that u(t) changes the availability of c(t + s). The delay may be a function of both the configuration and the decision. Some transitions between alternatives may be prohibited.

The objective function is the minimization of the expected present value of the sum of acquisition, operating, and penalty costs. The acquisition costs are a function of time, the existing configuration, and the configuration to which the system is to change. (This transition is determined by the decision variable.) The operating costs are a function of time, the system configuration, and the patient demand. The penalty cost is a function of time, the configuration, and the patient demand.

Penalty costs are incurred when a configuration does not possess enough total capacity or the correct type of capacity (the mix of intensive care, medium care, light care, and outpatient capacities) to meet the existing demand.

It is assumed that all future costs are specified by escalating current costs at given annual rates. Let $e_a(t)$, $c_o(t)$ and $e_p(t)$ be the escalation rates for acquisition, operating and penalty costs during subinterval t. Letting E

denote expected value over all possible demand levels, the objective function is given be

$$\text{Objective}(t) = \underset{\Omega(t,\, c(t))}{\text{Minimize}}\; E\left(\sum_{k=t}^{N-1} \left[\text{Acquisition cost}(k,\, c(k-1),\, c(k)) \prod_{\ell=o}^{k} \frac{1+e_a(\ell)}{1+g(\ell)} + \text{Operating Cost}(k,\, c(k),\, p(k)) \prod_{\ell=o}^{k} \frac{1+e_o(\ell)}{1+g(\ell)} + \text{Penalty Cost}(k,\, c(k),\, p(k)) \prod_{\ell=o}^{k} \frac{1+e_r(\ell)}{1+g(\ell)} \right] - S(N,\, C(N),\, p(N)) \right) \tag{3}$$

$$t = o, 1, 2, \ldots, N-1$$

where

t -- planning times

$g(t)$ -- cost of money during interval t

$c(t)$ -- configuration of facility at time t

$p(t)$ -- size and type of patient load at time t

N -- number of planning subintervals

$s(n, c, p)$ specifies the terminal value of the configurations and is included to account for the relative merit of ending the planning period in one configuration as opposed to others.

METHOD OF SOLUTION

In order to determine the strategy which minimizes the expected costs over the life cycle or over some other fixed period, patient demand projections over this same period of time must be available. These projections cannot be exact and therefore "fuzzy" projections are used with the "fuzziness" being determined by the likelihood of one demand level present as opposed to others. The total demand projection is given by Equation (2) where the user must specify

r(t), which determines the spread in the demand projections.

The construction cost for building each alternative completely and for altering or expanding from another alternative (if that transition is allowed) must be specified. The operating cost for each facility is divided into fixed and patient-load dependent costs. The patient dependent cost varies with the type of patient and the type of care unit available. For example, the cost of caring for an intensive care patient is less in an intensive care area than in a medium care area. (Depending upon future demand, this approach may be less expensive over the long term than upgrading some medium care units to intensive care units.)

In addition to construction and operating costs, a penalty cost is included to assign a dollar cost to the inability of a facility to service all the patients requesting service. This cost may reflect the measurable cost for service in another system and the expense involved in transporting the patient elsewhere, and subjective costs such as the inconvenience or degradation in the quality of care.

Dynamic programming determines the optimum time sequence for constructing or altering the health care system. At each decision point, the optimum strategy is determined for all possible demands and permissible configurations of the system. The objective function is the minimization of the expected sum of construction, operating and penalty costs discussed above.

The dynamic programming algorithm is not discussed here. The reader is referred to Reference 1. However, several features of the problem formulation and solution are discussed.

Dynamic programming imposes few restrictions on the type of objective function that may be used. All costs may be defined in tabular form, delays may be incorporated to account for design and construction time, and budget delays are easily included. Because the optimum strategies are determined as a function of the state variables, a planner can choose a nonoptimum policy and at a later time determine the optimum policy given his previous nonoptimum

decision. The planner is always using the most recent data available for the demand and system configuration. Also, by minimizing the expected value of the total costs, solutions are obtained which are acceptable for all possible demands (the acceptability depends upon the probability of a demand level occurring).

A planner is usually interested not only in the optimum strategy but also in comparisons between the optimum and nonoptimum strategies. For reasons which cannot be easily quantified and thus not included in the objective function, the planner may prefer a suboptimum policy if the incremental cost over the optimum is small. In addition, it is of interest to investigate the sensitivity of strategies, both optimum and nonoptimum, to change in demand, costs, delays in construction and, in general, any of the input data to the optimization program.

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1. R. Bellman and S. E. Dreyfus, "Applied Dynamic Programming", Princeton, N.J., Princeton University Press (1962).

2. P. H. Henault, R.B. Eastredt, J. Peschon, L.P. Hajdu, "Power System Long-Term Planning in the Presence of Uncertainty," Sixth PICA Conference Proceedings, May 1969.